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Programming and Control Handbook for Advanced TIROS-N Spacecraft Series (NOAA-H, NOAA-I, and NOAA-J) ~~AND K,L,M.~~ (SEE KLM SDR VOL 2)

Issued: August 28, 1987

Prepared for
National Aeronautics and Space Administration
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Greenbelt, Maryland

Prepared by
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Astro-Space Division
Princeton, New Jersey

Contract No. NAS5-28000

CONTENTS

CONTENTS (continued)

ILLUSTRATIONS

TABLES (continued)

TABLES (continued)

ILLUSTRATIONS (continued)

ILLUSTRATIONS (continued)

TABLES

18.0 INSTRUMENTS

18.1 ADVANCED HIGH RESOLUTION RADIOMETER (AVHRR)

18.1.1 FUNCTIONAL DESCRIPTION

18.1.1.1 Introduction

This section describes the five channel Advanced Very High Resolution Radiometer (AVHRR/2) developed by ITT-A/OD. The AVHRR/2 is used as the meteorological + oceanographical imaging system on the TIROS spacecraft.

The AVHRR/2 is an imaging system in which a small field of view (1.3 milliradians by 1.3 milliradians) is scanned across the earth from one horizon to the other by continuous 360° rotation of a flat scanning mirror. The orientation of the scan lines are perpendicular to the spacecraft orbit track and the speed of rotation of the scan mirror is selected so that adjacent scan lines are contiguous at the subsatellite (nadir) position. Complete strip maps of the earth from pole to pole are thus obtained as the spacecraft travels in orbit at an altitude of approximately 450 n. miles (833 km). All five spectral channels of the AVHRR/2 are registered so that they all measure energy from the same spot on the earth at the same time. All five channels are also calibrated so that the signal amplitude in each channel is a measure of the scene radiance. The radiometers are designed to operate within specification for a period of two years in orbit.

18.1.1.2 Data Products

The AVHRR data are used to produce the following four data products.

(a) Continuous spacecraft-recorded Global Area Coverage (GAC) data from the AVHRR will be provided. The GAC data are at 4-km resolution. The global data are required at the central processing facility with minimum delay for use in numerical prediction models and will be routinely recovered by the two existing Command and Data Acquisition (CDA) stations.

(b) Spacecraft storage of data from selected Local Area Coverage (LAC) (approximately 10 min) of each orbit at high resolution (1 km) for central processing will be provided.

(c) Continuous direct readout of two channels of AVHRR data to ground stations of the Automatic Picture Transmission (APT), worldwide, at low resolution (4 km) will be provided. Reduction of panoramic distortion will be accomplished by the Manipulated Information Rate Processor (MIRP). The continuous real-time transmission of sounder data to this class of stations will be provided.

(d) Continuous direct readout of four (or five, where applicable) channels of AVHRR data of the High Resolution Picture Transmission (HRPT), worldwide, (l-km resolution) will be provided to the ground stations.

18.1.2 SYSTEM DESCRIPTION

18.1.2.1 General

The **AVHRR/2** is a five channel scanning radiometer providing two channels in the visible near infrared region and three infrared channels. The **AVHRR/2** has two one-micrometer wide channels between 10.3 and 12.5 **μm.** The instrument utilizes an 8 inch diameter collecting telescope of the reflective Cassegrain type. Cross-track scanning is accomplished by a continuously rotating mirror direct-driven by a hysteresis synchronous motor. The three infrared detectors are cooled to 105 Kelvin by a two-stage passive radiant cooler. The data from the five channels is simultaneously sampled at a 40 kHz rate and converted to 10-bit binary form within the instrument.

A summary of the AVHRR/2 characteristics is given in Table 18. l-l. Figure 18.1-1 shows the outline configuration of the instrument.

The **AVHRR/2** is comprised of five modules which are assembled together into a single unit instrument. These modules are:

Scanner Module
Electronics Module
Radiant Cooler Module
Optical Subsystem
Baseplate Unit

These modules are shown in the exploded view of Figure 18.1-2.

18.1.2.2 The Scanner Module

This module includes the scan motor, the mirror and the scan motor housing. The scan motor design is based on the motor developed for the SCMR (Surface Composition Mapping Radiometer), an 80 pole hysteresis synchronous motor. The motor has two power modes of operation and is normally operated in the high-power mode ($\sim$ 4.5 watts) in orbit in order to minimize scan line jitter. The scanner housing is an integral part of the motor and is made of beryllium. The scan mirror is also made of beryllium and is $\simeq$ 11.6 inches across the major axis and 8.25 inches across the minor axis. The scan motor rotates the mirror at the 360 RPM to produce a contiguous scan of the earth scene. The line-to-line jitter is less than 17 microseconds.

18.1.2.3 Electronics Module

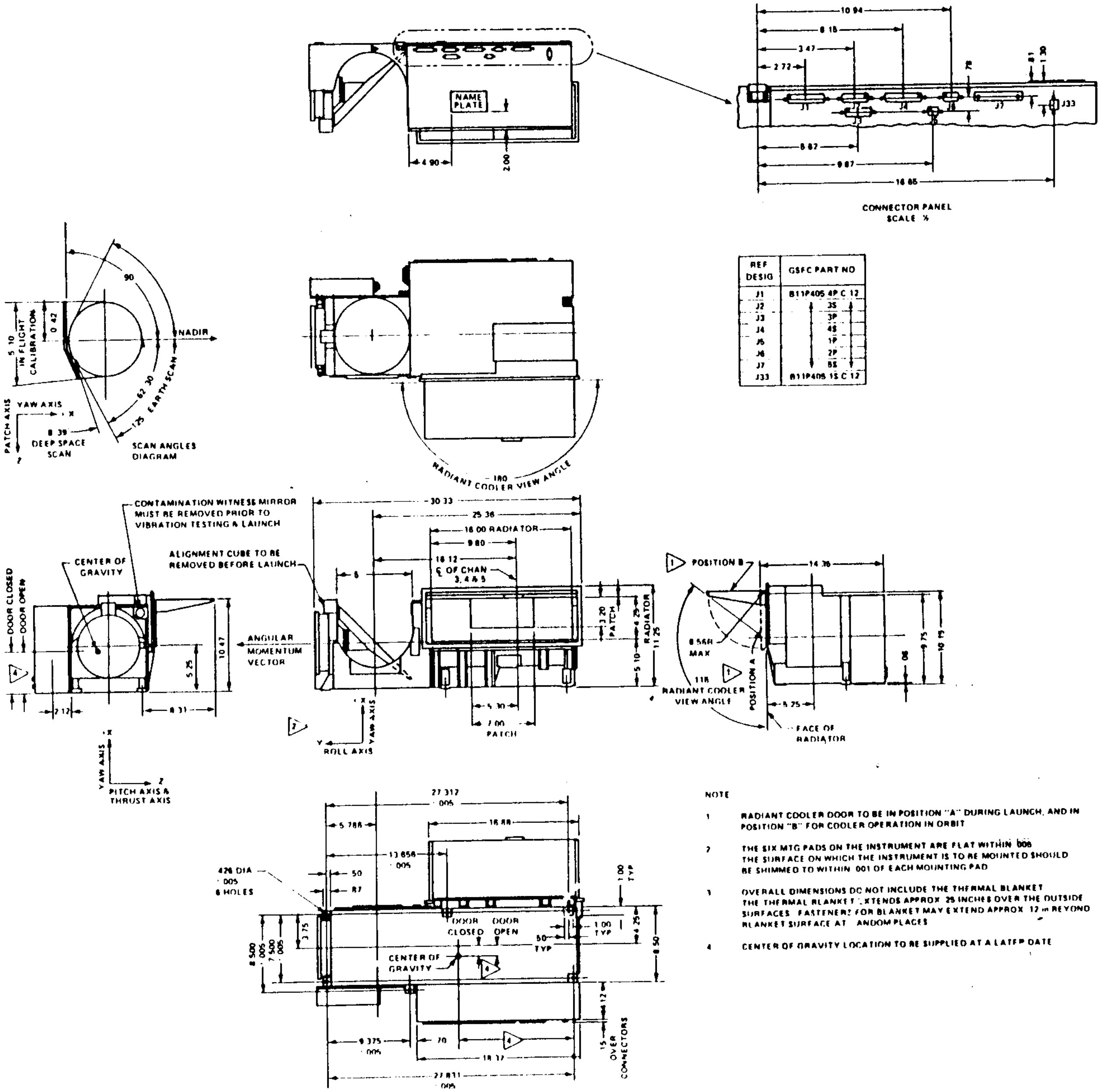
The electronics module is in two sections both of which bolt on to the instruments inboard side panel. The curved box (Reference Figure 18.1-2) is the motor power supply. Twenty-five

Table 18.1 – 1 Summary of AVHRR/2 Characteristics

	Ch 1	Ch 2	Ch 3*	Ch 4*	Ch 5
Spectral Range (μM)	.58–.68	.725–1.O	10.3-11.3	3.55–3.93	11.5–12.5
Detector Type	Silicon	Silicon	HgCdTe	InSb	HgCdTe
Resolution (N. Mi.)	.59	.59	.59	.59	.59
IFOV** (milliradian)	1.3 sq.	1.3 sq.	1.3 sq.	1.3 sq.	1.3 sq.
S/N @ .5% Albedo	> 3:1	> 3:1	—	—	—
NETD @ 300K	—	—	⩽ .12K	⩽ .12K	⩽ .13K
MTF (1IFOV/Single Bar)	> .30	> .30	> .30	> .30	> .30

Optics	–	8 inch diameter afocal Cassegrain telescope
Scanner	–	360 rpm hysteresis synchronous motor with ribbed beryllium scan mirror
Cooler	–	two-stage radiant cooler, IR detectors controlled at 105K
Data Output	–	10 bit binary, simultaneous sampling at 40 KHz rate
Commands	–	28
Telemetry	–	14 digital, 20 analog
Power	–	28.5 watts max.
Size	–	31" x 11" x 16" max. (See Figure 18.1-1)
Weight	–	65 pounds max.

* NOAA designation of channels 3 and 4 are reversed.
**Tolerance of IFOV values are ± 0.2 m.r.



REF DESIG	GSFC PART NO
J1	B11P405 4P C 12
J2	3S
J3	3P
J4	4S
J5	1P
J6	2P
J7	5S
J33	B11P405 1S C 12

NOTE

1 RADIANT COOLER DOOR TO BE IN POSITION "A" DURING LAUNCH, AND IN POSITION "B" FOR COOLER OPERATION IN ORBIT

2 THE SIX MTG PADS ON THE INSTRUMENT ARE FLAT WITHIN 006 THE SURFACE ON WHICH THE INSTRUMENT IS TO BE MOUNTED SHOULD BE SHIMMED TO WITHIN 001 OF EACH MOUNTING PAD

3 OVERALL DIMENSIONS DO NOT INCLUDE THE THERMAL BLANKET THE THERMAL BLANKET EXTENDS APPROX 25 INCHES OVER THE OUTSIDE SURFACES FASTENERS FOR BLANKET MAY EXTEND APPROX 12 in BEYOND BLANKET SURFACE AT ANDOM PLACES

4 CENTER OF GRAVITY LOCATION TO BE SUPPLIED AT A LATER DATE

Figure 18.1 1.

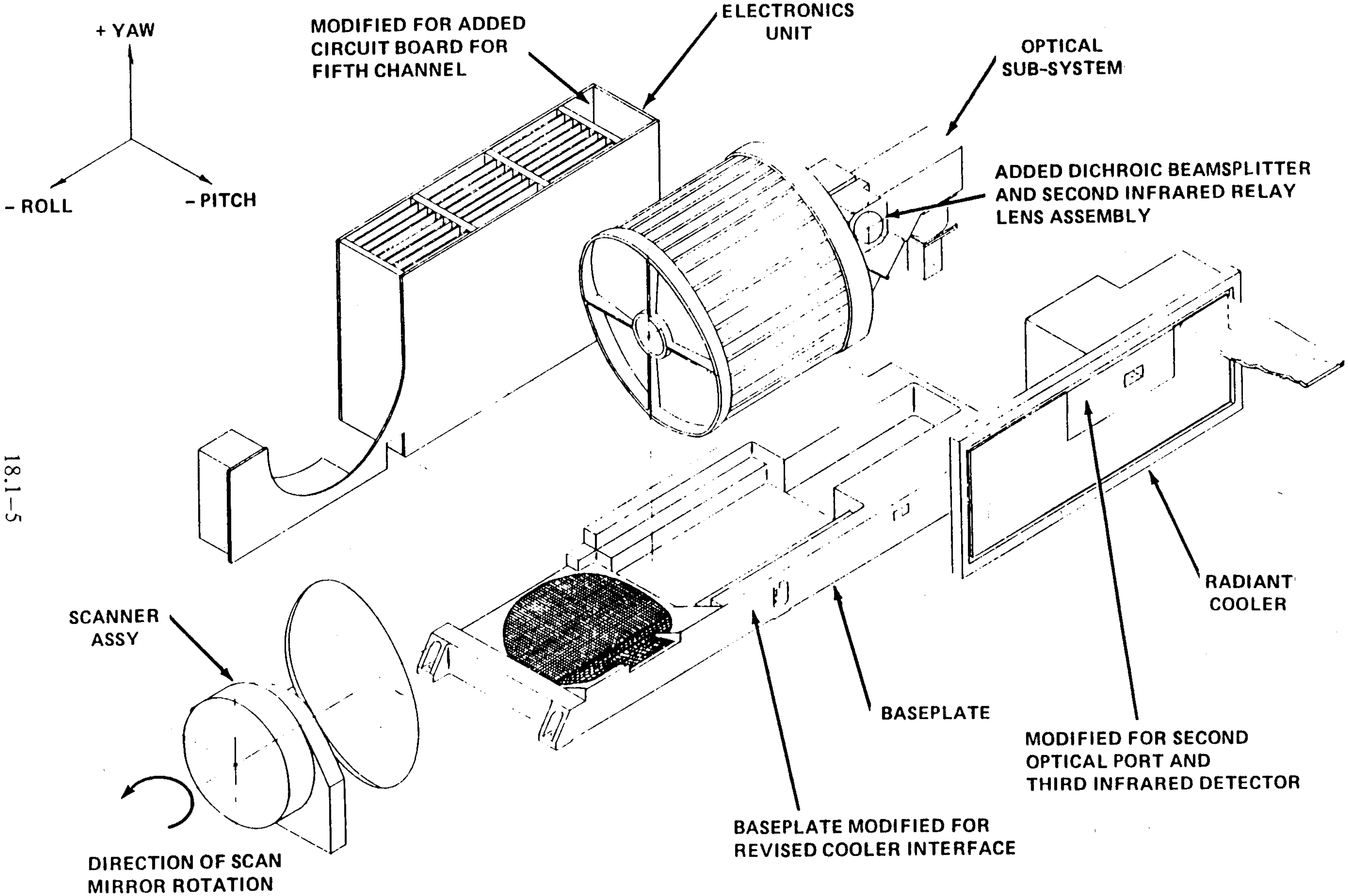


Figure 18.1–2. AVHRR/1 modules with modifications indicated for five channel AVHRR/2.

electronic boards are used to make up the electrical system of the AVHRR. Nineteen of these are located in the electronics box. The visible channel preamplifiers for the visible channels and IR channels 3 and 5 are located in the area of the secondary optics. The IR channel 4 preamplifier is located on the rear of the radiant cooler housing.

18.1.2.4 Radiant Cooler

The radiant cooler module is made up of four basic assemblies. These are (1) the cooler housing, (2) the first stage radiator, (3) the patch or second stage radiator, and (4) the cooler cover. The first stage radiator is configured in such a manner as to shade most of its radiating area from the earth by the cooler cover when the cover is deployed. A "single shot" solenoid actuated, spring driven deployment system is used to deploy the cover. Mounted on the cold (105 Kelvin) patch are the three infrared detectors. The patch has a 22.4 in^2 radiating area. The cooler housing surrounds the cooler on all sides except for the radiation area.

Multilayer insulation thermally separates the first stage radiator from the housing and the first stage optical window is tnermally isolated and heated several degrees warmer than the 17 1 K radiator temperature to prevent condensation on it. The patch is thermally isolated from the first stage by low emissivity surfaces (gold to gold) and runs at 98K with no control power. During nominal operation the patch temperature will be controlled at 105K.

18.1.2.5 Optical Subsystem

The optical subsystem consists of two separable subassemblies, a collecting telescope and a relay optics unit. The telescope is an 8.0 inch diameter aperture, reflective Cassegrain of afocal design (collimated output). The relay optics split the telescope exit beam into five discrete spectral bands and focus them onto their respective field stops. The spectral bands are:

Channel 1: 0.58 to 0.68 micrometers
Channel 2: 0.72 to 1.05 micrometers
Channel 3: 10.3 to 11.3 micrometers
Channel 4: 3.55 to 3.93 micrometers
Channel 5: 11.5 to 12.5 micrometers

The instantaneous field of view is 1.3 by 1.3 milliradians in all channels and is defined by an aperture plate in Channels 1 and 2 and by the detector active areas in Channel 3, 4 and 5. In addition, the optical subsystem has been designed to meet the total system MTF requirements with the detectors registered off axis by as much as 1.5 milliradians in Channels 1 and 2 and 1 milliradian in Channels 3, 4 and 5.

Polarization effects have been minimized (<7% in Channels 1 and 2) by orienting the polarization sensitive elements in a predetermined way, thus having some elements compensate for other elements. This assembly is shown in Figure 18.1–3.

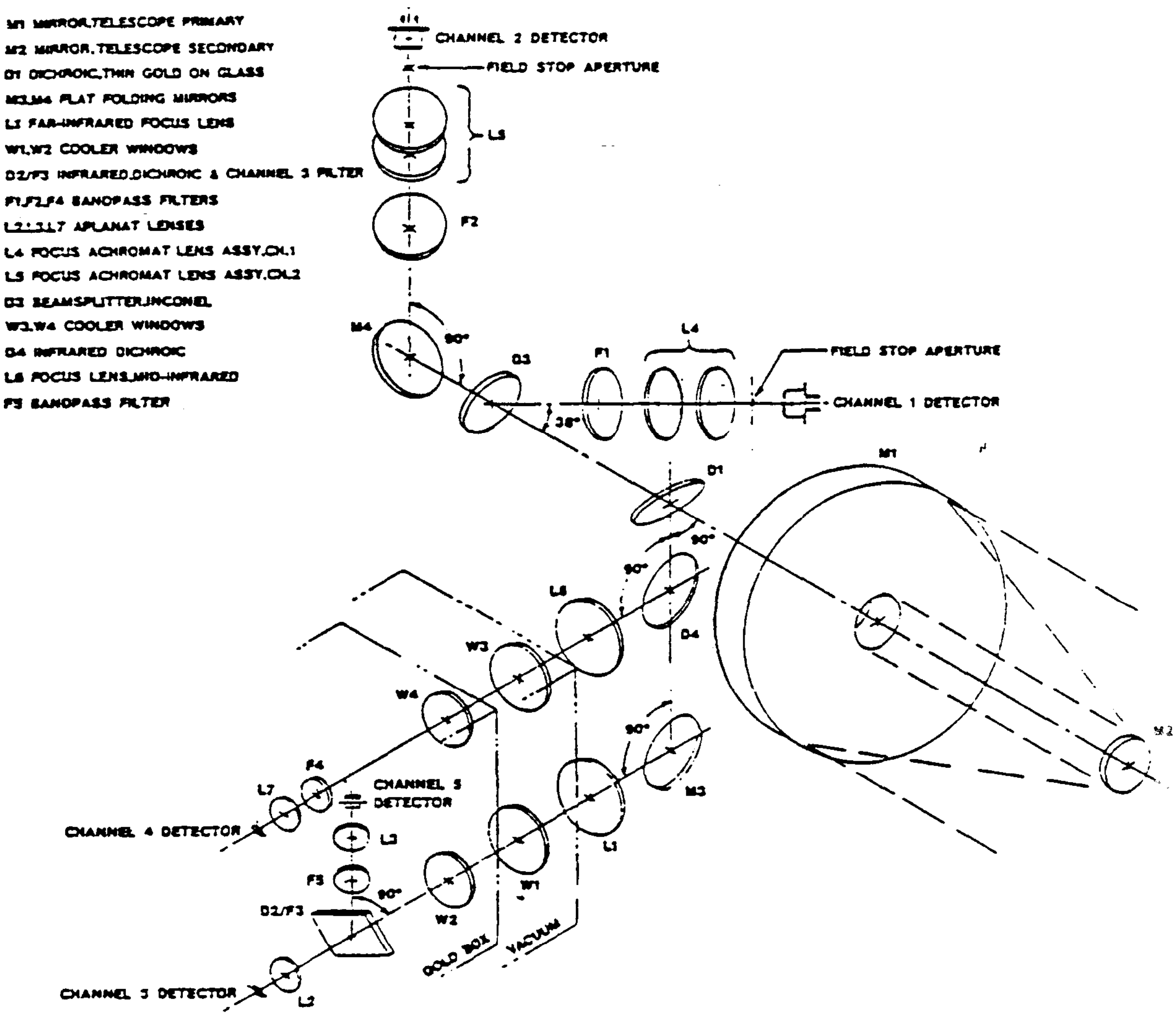


Figure 18.1-3 AVHRR/2 optical configuration.

18.1.2.6 Baseplate Unit

The baseplate unit is the common structure to which all other modules are secured. Dowel pins are used to establish and maintain alignment of the scanner and optics modules. Alignment of the cooler to the optics is established by shims.

18.1.2.7 AVHRR Data

The output data signals supplied by the instrument to the spacecraft fall into three categories: outputs to the MIRP, digital-B telemetry, and analog telemetry.

The specific signals supplied by the AVHRR are detailed in the following paragraphs.

'18.1.2.7.1 AVHRR Outputs to the MIRP – The data from each of the five channels will be digitized in the radiometer to a IO-bit word and brought out of the instrument as a IO-bit parallel digital output to the spacecraft MIRP. In addition to these digital signals. the line synchronization signal will also be routed to the MIRP on a separate buffer isolated line.

18.1.2.7.1.1 Line Synchronization Pulse – A line synchronization pulse will be sent to the MIRP at the beginning of each mirror scan. The characteristics of this pulse are as follows:

(a) Duration – 100 μsec
(b) Repetition Rate – 6 pps
(c) Noise Spikes – Less than 1/4 signal amplitude
(d) Scan Line to Scan Line Jitter:

(1) Less than 17.2 μsec for 98 percent of jitter measurements taken every scan line over a 20-min period.
(2) Less than 34.4 μsec between any two scan lines within a 20-min period.

(e) Pulse Level – The sync line output is normally at ground level (0.0 to +0.4V). The sync line output goes to the +5V level (+2.40 to +5.25V) for the duration of each sync pulse.
(f) Shielding – The shield of the sync line is tied to AVHRR chassis ground.

18.1.2.7.1.2 Radiometric Data Lines – A separate analog video signal is generated within the AVHRR for each of the radiometric channels in the instrument. The data for each channel is converted to a single IO-bit digital word prior to being transferred to the MIRP. Upon receipt of a Data SamplePulse, thedigital words(one for each radiometric channel) are transferred sequentially to the MIRP. The data in each word is transferred by parallel readout of the IO-bit word through ten output data lines.

(1) Content. The information content of each data channel is shown in Table 18.1-Z.
(2) Digitization: 10–bit words
(3) Output: Parallel readout. 10 bits
(4) Output Timing: Initiated by each Data Sample pulse as shown in Figure 18. 1–4. Timing details are as follows:

Transfer of AVHRR digitized data will be accomplished by 10 parallel lines representing parallel word transfer. At 5T ± 300 nanoseconds after each sample time (the negative going edge of the clock which is coincident with the high or true state of the sample pulse) the AVHRR will transfer parallel digitized channel 1 data to an output register and hold it there for 5T ± 300 nanoseconds. Data from the remaining AVHRR channels will be successively transferred into the output register as follows:

Channel 2 transfer time is 10T ± 300 nanosecondsafter sample time.data is held for 5T ± 300 nanoseconds. Channel 4 transfer time is 15T ± 300 nanoseconds, data is held for 5T ± 300 nanoseconds. Channel 3 transfer time is 20T ± 300 nanoseconds. data is held for 5T ± 300 nanoseconds. Channel 5 transfer time is 25T ± 300 nanoseconds. data is held for 5T minimum. 10T maximum ± 300

Table 18.1–2 AVHRR Channel Content

	Chan. 1	Chan. 2	Chan. 3	Chan. 4	Chan. 5
Deep Space (Clamp)	X	X	X	X	X
Ramp Calibration Signal(‘)	X	X	X	X	X
Earth Scene (Visible)	X	X			
Earth Scene (IR)			X	X	X
IR Target Temperature(*)			X	X	X
Cooler Patch Temp.			X	X	X
Backscan Target IR Data			X	X	X

Notes:

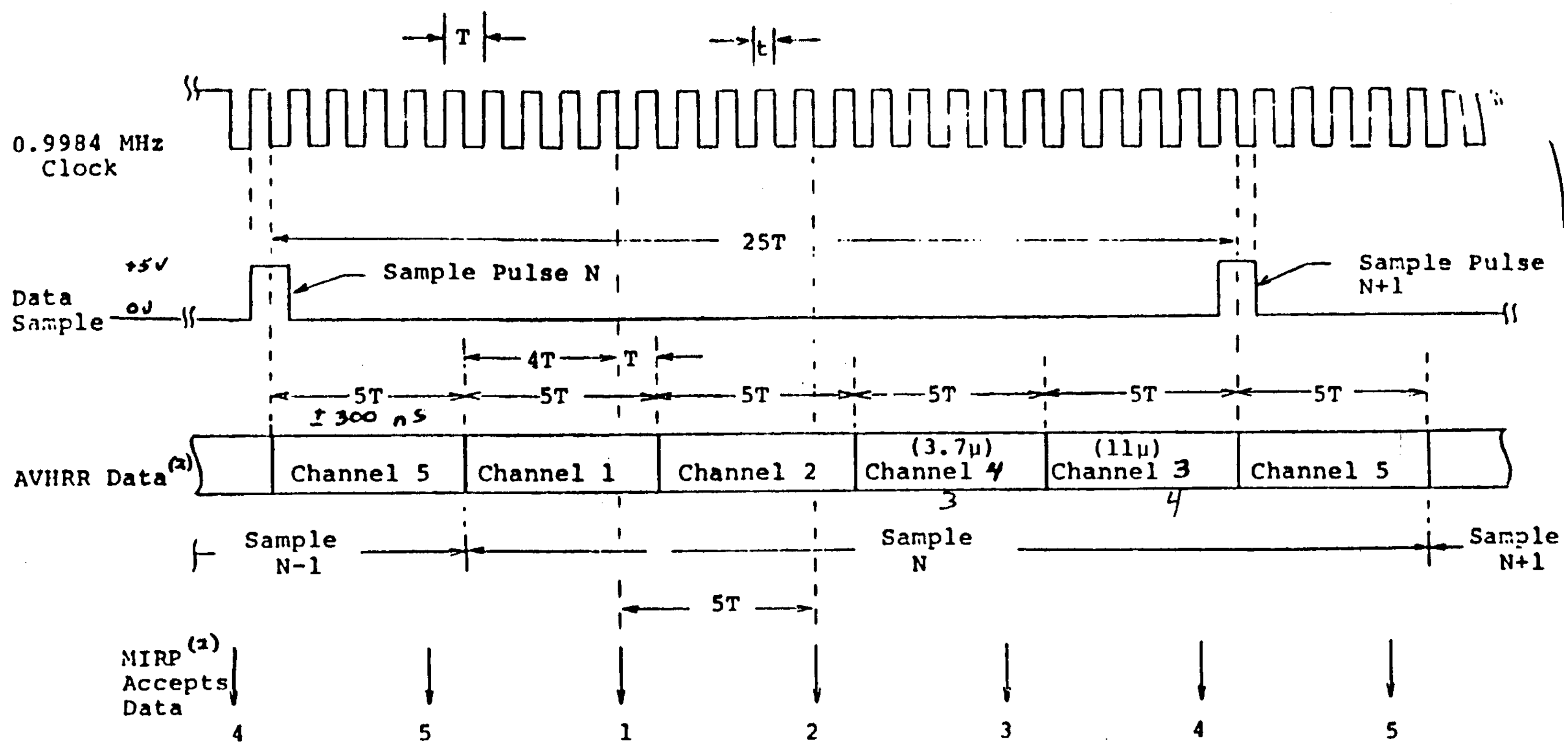
[1]The ramp calibration signal will consist of the output of a D/A generator which increases one step per revolution of the radiometer scanning system. A ramp shall be generated every 1024 scans of the radiometer. The ramp voltage shall vary from -0.025 to +6.475 volts in 1023 steps of 0.0063 volt, and shall have a precision of 10 bits.*

[2]The temperature of the backscan calibration target shall be measured using four platinum resistance temperature detectors.

The signal from each of the platinum resistance temperature detectors in the radiometer housing calibration target shall be inserted into the composite analog video signal in each Chann[illegible] [illegible] signal per scan line, following the start of the space scan as shown in Table 18.1-4. The signal [illegible] the first temperature detector shall be inserted in the fist scan line; the signal from the second [illegible] ature detector shall be inserted in the second scan line, etc., until all of the temperature [illegible] have been interrogated.

For TIROS-(H, I, & J), the scan line immediately following the line which [illegible] signal from the last temperature detector shall be blank (clamped to 0 volts which [illegible] different from the temperature signal) in the region allocated for the tempera:?. [illegible] signal. The interrogation sequence shall be repeated starting with the next scan line.

*The digitizer has a range from 0 to 4.39375 volts in 1023 steps of 0.00625 volts. As a result, the nominal ramp cal output will skip a step approx. once every 62 steps and the low voltage end of the ramp (beginning of ramp for channels 1& 2, and end of ramp for channels 3, [illegible]) will have approximately 5 “0” values, while the high voltage end of the ramp will have approximately 14 “ 1023” values.



NOTES:

1) $T = \frac{1}{0.9984 \times 10^{+6}}$ sec.
2) AVHRR Channel identification shown (as opposed to MIRP ID's),
3) Sample input is normally at ground level (0.0* to +0.4V)
4) Sample goes to +5V level (+4.0V to 5.25V) for duration of each sample pulse.
5) Channel 5 is a repeat of Channel 3 for AVHRR/1 only.
6) $0.4\ T \leq t \leq 0.6\ T$.

*This could go to -0.01V at the AVHRR if there is 90 mA flowing in the AVHRR Signal Ground.

Figure 18.1–4. MIRP/AVHRR Interface timing.

nanoseconds. Transfer of data from the AVHRR output register to the spacecraft processor will occur 0.5T to 4.5T after the start of each channel output time interval.

(5) Sample Rate

The number of samples taken by the MIRP as a function of scan time is shown in Table 18.1-3.

Table 18.1–3 MIRP Data Sample Intervals

AVHRR Output Information	Begin Sample Period		End Sample Period		Number of Samples Generated
	Time (Millisec)	Clock Counts	Time (Millisec)	Clock Counts	
Detector: Space View	+ 2.529	2,525	+ 2.779	2,775	10
Electronic Ramp Cal.	+ 3.756	3,750	+ 3.781	3,775	1
Detector: Earth View	+ 8.614	8,600	+ 59.895	59,800	2048
TLM: IR Target Temp.	+ 65.780	65,675	+ 65.805	65,700	1
TLM: Patch Temp.	+ 66.006	65,900	+ 66.031	65,925	1
None	—	—	—	—	0
Detector: IR Backscan	+118.064	117,875	+118.314	118,125	10
None			—	—	0

Notes:

1. T_o is the leading edge of the AVHRR line sync.
2. T = 1.00160256 μs = one 0.9984 MHz clock period = one count
3. All "Times" and "Counts" are in appropriate units after T_o.
4. AVHRR Scan Period = 1/6 second = 166.67 ms
5. Nominal Nadir = To + 34.255 msec or To + 34,200 counts
6. Sample Pulse Spacing = 25T during sample periods (39,936 pps)

(6) Pulse Level

a) A Data "1" is a +2.40 to +5.25 Volt Level
b) A Data "0" is a 0.0 to +0.4 Volt Level

(7) Data word rate to MIRP: 199,680 words per second.

(8) Bit Position

a) The MSB of Radiometric Data is located on Data Line 1 for each channel.
b) The LSB of Radiometric Data is located on Data Line 10 for each channel.

(9) Radiometric Range

Scene	Ch. 1 & 2	Ch. 3 & 4
VIS; 100% Albedo (White)	+6.1V	
IR: Space (Cold)		+6.2V
VIS: Black	+0.25V	
IR: 320°K (Hot)		+0.3V

18.1.2.7.1.3 Calibration Data

(1) Line by Line Calibration

The AVHRR Calibration data consists of the following parameters which are inserted in each scan line:

Parameter	Channel Location	Timing
a) Space Sample	Table 18.1-2	Tables 18.1-3 & 18.1-4
b) Electronic Calibration Ramp	,,	,,
c) IR Target Temp. TLM	,,	,,
d) Patch Temp. TLM	,,	,,
e) IR Target Sample	,,	,,

See Table 18.1-5 for the nominal voltage calibration.

(2) Simulated Calibration Signal

The simulated calibration signal shall be substituted for the actual detector output upon command. The following data will appear in all channels.

Parameter	Timing
a) Space Sample	Tables 18.1-3 & 18.1-4
b) Ramp Calibration Signal	,,
c) Simulated Earth Scan*	,,
d) Simulated Cal. Targets	,,

*The simulated Earth scan provides three voltage levels in a cyclic pattern on successive scan lines for each channel. This provides an effective 3 point voltage calibration check. See Table 18.1-5 for the nominal Earth Scan levels.

Table 18.1-4 Scan/Calibration Timing (Nominal Orbit)

a) Scan Timing

Scan Timing Units*

0	TO	0.1	Line Sync
0.5	TO	1.5	MIRP pm-cursor time
		1.8	Space view start
1.9	TO	3.5	Space sample
3.5	TO	4.0	Ramp cal
		4.13	Space end – worst case early S/C attitude and orbit
		4.8	Space end – worst case early – S/C attitude
		5 3	Space end – nominal
		5.8	Space end – worst case late – S/C attitude
		34.2	Nadir nominal
		42.6	Space start – worst case early – S/C attitude
		63.1	Space start – nominal
		63.6	Space start – worst case late
65.6	TO	65.8	IR target temp
65.8	TO	66.0	Patch temp
		117.1	IR cal target – full view start
117.6	TO	118.4	IR cal target sample
		119.0	IR target – full view end
165.0	TO	166.4	MIRP pre–cursor time

b) Simulated Voltage Calibration Signals

4.0	TO	65.6	Simulated earth scene
117.6	TO	118.4	Simulated cal target

c) Auxiliary Scan Timing

1.8	TO	1.9	1st space sample
3.4	TO	3.5	2nd space sample
51.2	TO	76.8	Back edge space blanking
160.0	TO	12.9	Space window

*Scan Timing Unit = STU = 1 .OO 1602564 milliseconds = 1,000 counts

Table 18.1-5 AVHRR Voltage Calibration Levels
(All levels are nominal values)

1. Calibration Ramp

Scan Line #	1	=	-0.02 volts
	128	=	+0.79
	256	=	+1.60
	384	=	+2.41
	512	=	+3.23
	640	=	+4.04
	768	=	+4.86
	896	=	+5.67
	1024	=	+6.48

2. Simulated Earth Scene

	Channels 1 & 2	Channels 3, 4 & 5
Level 1	+1.92 volts	+4.52 volts
Level 2	+3.50 volts	+2.95 volts
Level 3	+5.18 volts	+ 1.28 volts

3. Simulated Backscan Calibration Target

Channels 1, 2	+6.0 1 volts
Channels 3, 4 & 5	+0.44 volts

18.1.2.7.2 Digital "B" Telemetry

18.1.2.7.2.1 General – The Digital "B" one-bit status telemetry are available at the instrument interface at all times. The 3.2 second subcom generated by the TIP will sample each Digital "B" Telemetry Point once every 3.2 seconds. The characteristics of the Digital "B" telemetry interface are detailed in Sections 3 .1.6, 3.1.8.2, and 3.1.8.3 of the General Instrument Interface Specification.

18.1.2.7.2.2 Digital "B" Telemetry Points – The Digital "B" Telemetry Points provided by the AVHRR are listed in Table 18.1-6.

Each of the 14 Digital "B" telemetry points listed in Table 18.1-6 indicates the status of one of the 14 pairs of commands listed in Table 18.1–7.

Table 18.1-6 AVHRR Digital “B” Telemetry

No.	Telemetry Point Name	State*		TIP		
		Logic “1”	Logic “0”	Minor Frame	Ch. #	Word 8 Bit #
1	Scan Motor/Telemetry Status	On	Off	20	244	8
2	Electronics/Telemetry Status	On	Off	20	212	7
3	Channel I Status	On	Off	21	53	2
4	Channel 2 Status	On	Off	21	85	3
5	Channel 3 Status (11μ)	On	Off	21	117	4
6	Channel 4 Status (3.7~)	On	Off	21	149	5
7	Voltage Calibrate S tatus	On	Off	20	148	5
8	Patch Control Mode Status	108 °K	105°K	20	84	3
9	Cooler Heat Status	On	Off	20	180	6
10	Scan Motor Mode Status	High Power	Low Power	20	116	4
11	Housekeeping Telemetry Lock Status	Locked On	Not Locked On	21	21	1
12	Earth Shield Status	Deploy	Disable	20	20	[illegible]
13	Patch Control Status	On	Off	20	52	2
14	Channel 5 Status	On	Off	21	181	6

Notes:

*Logic “ 1” is a “True” or “Low Voltage” state.

18.1.2.7.3 Analog Telemetry

18.1.2.7.3.1 General – The Analog Telemetry shall be available at the instrument interface at all times.* Three different subcoms (32, 16, l-second) generated by the TIP will be used to sample spacecraft analog telemetry. TIP Minor frame words 9, 10, and 11 are dedicated to these subcoms respectively. The characteristics of the analog telemetry interface are detailed in Sections 3.1.6, 3.1.8.2, and 3.1.8.3 of the General Instrument Interface Specification.

*Analog telemetry is available when one of more of the following conditions is satisfied. (1) Scan Motor/Telemetry is On, (2) Electronics/Telemetry is On, or (3) Telemetry is Locked On.

Table 18.1-7 Spacecraft/AVHRR Command Interfaces

No.	Command Name [2]	Mne-monic	CIU Buffer Bit	Reset Logic State[1]
1	Scan Motor/Telemetry On	ASMTN	20E/1	F
2	Scan Motor/Telemetry Off	ASMTF	20E/2	F
3	Electronics/Telemetry On	AELTN	20E/3	F
4	Electronics/Telemetry Off	AELTF	20E/4	F
5	Channel 1 Enable	ACH1E	20E/5	F
6	Channel I Disable	ACH1D	20E/6	F
7	Channel 2 Enable	ACH2E	298/1	F
8	Channel 2 Disable	ACH2D	298/2	F
9	Channel 3 Enable } 11μ	ACH3E	20E/9	F
10	Channel 3 Disable	ACH3D	20E/10	F
11	Channel 4 Enable } 3.7μ	ACH4E	298/5	F
12	Channel 4 Disable	ACH4D	298/6	F
13	Cooler Heat On	ACHON	298/3	F
14	Cooler Heat Off	ACHOF	298/4	F
15	Telemetry Locked On	ATLON	298/9	F
16	Telemetry Not Locked On	ATNLO	298/10	F
17	Earth Shield Deploy	AESDP	298/11	F
18	Earth Shield Disable	AESDI	298/12	F
19	Patch Control On	APCON	20E/13	F
20	Patch Control Off	APCOF	20E/14	F
21	Channel 5 Enable	ACH5E	20E/15	F
22	Channel 5 Disable	ACH5D	20E/16	F
23	Voltage Calibrate On	AVCON	20E/7	F
24	Voltage Calibrate Off	AVCOF	20E/8	F
25	Patch Control High Mode	APCHM	20E/11	F
26	Patch Control Low Mode	APCLM	20E/12	F
27	Scan Motor High Mode	ASMHM	298/7	F
28	Scan Motor Low Mode	ASMLM	298/8	F

Notes:

[1] State assumed when CIU is reset at power turn-on. T = True = 0 Volts; F = False = + 10V

[2] All commands are "pulse discretes."

18.1.2.7.3.2 Analog Telemetry Points – The analog-telemetry* points provided by the AVHRR are listed in Table 18.1-8**. Electrical characteristics of the analog telemetry electrical interface are shown in Figure 15 through 18. A detailed description of each telemetry point is as follows.

1. Patch Temperature. This telemetry point measures the output from platinum temperature sensor located on the radiant cooler patch which contains the IR detector. The amplifier gain/offset is adjusted for the patch temperature range.

2. Patch Temperature Extended. This telemetry point measures the output from the platinum temperature sensor located on the radiant cooler patch which contains the IR detectors. The amplifier gain/offset is adjusted for the extended temperature range of the patch.

3. Patch Power. This telemetry point measures the DC voltage being applied to the control heater on the radiant cooler patch which contains the IR detector.

4. Radiator Temperature. This telemetry point measures the output from the platinum temperature sensor located on the first stage (warmer stage) of the radiant cooler.

5-8. Black Body No. 1,2,3,4. These telemetry points measure the outputs of platinum temperature sensors No.'s 1 through 4, respectively, located on the black body calibration target.

9. Electronics Current. This telemetry point measures the DC current load on the +28 volt bus (pins 1 and 2 on J3). This is directly proportional to the DC current into the power converters for the remaining electronics not including the motor power supply.

10. Motor Current. This telemetry point measures the DC current load on the +28 volt (motor) bus (pins 3 and 4 on J3). This is directly proportional to the DC current into the scan motor power supply.

11. Earth Shield Position. This telemetry point indicates the status of the radi cooler earth shield.

12. Electronics Temperature. This telemetry point measures the output of the thermistor located inside the electronics box.

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*Analog telemetry is available when one or more of the following conditions is satisfied: (1) Scan Motor/Telemetry is On, (2) Electronics/Telemetry is On, or (3) Telemetry is Locked On.
**Algorithms for converting telemetry volts to engineering units are given for each model of the AVHRR in the "Alignment and Calibration Data Book" for that model. Those algorithms are similar, but not identical, among the several models.

13. Cooler Housing Temperature. This telemetry point measures the-output from a thermistor located on the radiant cooler housing.

14. Baseplate Temperature. This telemetry point measures the output of the thermistor located on the baseplate as shown on the Thermal Interface Drawing.

15. Motor Housing Temperature. This telemetry point measures the output from a thermistor located on the scan motor housing.

16. A/D Converter Temperature. This telemetry point measures the output of a thermistor located inside the A/D converter at the point of maximum sensitivity to heat.

17. Detector Bias Voltage Channel 3. This telemetry point measures a voltage directly proportional to the regulated -12 volt DC which supplies the Channel 3 IR detector bias current.

18. Black Body Temperature, IR Channel 3 (11μ). This telemetry point measures the output of a sample-and-hold circuit which samples the IR Channel 3 analog data signal once each scan line when viewing the black body calibration target.

19. Black Body Temperature, IR Channel 4 (3.7~). This telemetry point measures the output of a sample-and-hold circuit which samples the IR Channel 4 analog data signal once each scan line when viewing the black body calibration target.

20. Reference Voltage. This telemetry point measures a DC voltage proportional to the +6.4 volt reference voltage source in the electronics.

2 1. (Not used on AVHRR/I) – Detector Bias Voltage Channel 5. This telemetry point measures a voltage directly proportional to the regulated -12 volts DC which supplies the Channel 5 IR detector bias current.

22. (Not used on AVHRR/I) – Black Body Temperature, IR Channel 5. This telemetry point measures the output of a sample-and-hold circuit which samples the IR Channel 5 analog data signal once each scan line when viewing the black body calibration target.

18.1.2.8 Instrument Interfaces

The instrument interfaces consist of power, command, telemetry data systems. The data is controlled and directed through the MIRP. All electrical connections to the AVHRR/2 are made through the connectors listed in Table 18.1-g. A test connector is provided for use in the subsystem and system test at the instrument level. This connector (J7) is capped and not used in spacecraft testing or operation. The requirements of the General Instrument Interface Specification (GIIS) IS-2280259 are followed in the connection, operation and control of interfaces to the spacecraft.

Table 18.1–8 AVHRR Analog Telemetry

No.	Telemetry Point Name	TIP			Range	Resolution
		Sub-Com	Minor Frame	Channel #		
1	Patch Temperature	32	45	45	+0.2V = 90.7°K +5.0V = 115.5°K	0.1935V/degree
2	Patch Temperature Extended	32	29	29	+0.2V = 99.4°K +5.0V = 316.0°K	0.02216V/degree
3	Patch Power	32	5	5	+0.2V = 0.08 MW +5.0V = 50.0 MW	MW = 2V² (0.067V/MW at 32 MW out)
4	Radiator Temperature	32	53	53	+0.2V = 145.7°K +5.0V = 317.3°K	0.0285V/degree
5	Blackbody Temp. 1	32	93	93	+0.2V = 5.08°C +5.0V = 44.97°C	0.12033091V/degree
6	2	32	165	165		
7	3	32	173	173		
8	4	32	181	181		
9	Electronics Current	16	54,134 214,294	372	+0.2V = 39.3 MA +5.0V = 982.5 MA	5.088 MV/Milliamp.
10	Motor Current	16	55,135 215,295	380	+0.2V = 12 MA +5.0V = 300 MA	16.6 MV/Milliamp.
11	Earth Shield Position	32	37	37	3 levels	1.15V Fully closed 2.99V In between 4.99V Fully open
12	Electronics Temperature	32	69	69	+0.2V = 38.73°C +5.0V = 10.8°C	0.17174V/°C

Table 18.1–8 AVHRR Analog Telemetry (Continued)

No.	Telemetry Point Name	TIP			Range	Resolution
		Sub-Com	Minor Frame	Channel #		
13	Cooler Housing Temperature	32	61	61	+0.2V = 33.24°C +5.0V = +3.95°C	
14	Baseplate Temperature	32	77	77		
15	Motor Housing Temperature	32	85	85		
16	A/D Converter Temperature	32	189	189	+0.2V = 84.49°C +5.0V = 44.51°C	0.129V/°C
17	Detector #3 Bias Volt.	32	21	21	Single level at +2.15V	0.231V/V
18	Blackbody Temp. IR CH 3*	32	197	197	To Be Calibrated	
19	Blackbody Temp. IR CH 4**	32	205	205	To Be Calibrated	
20	Reference Voltage	32	13	13	Signal level at +4.8V	0.750V/V
21	Det. #5 Bias Volt[1]	32	247	247	Single level at +2.15V	0.231V/V
22	BB Temp. IR CH5[1]	32	252	252	To Be Calibrated	

*11μ
**3.7μ
[1]Not used on AVHRR/1.

Table 18.1-9 Interface Connectors

No.	Function	GSFC Style	Description
J1	Command	311P405-4P-C-12	37 Pin Male
J2	Digital TM	311P405-3S-C-12	25 Pin Female
J3	Power	311P405-3P-C-12	25 Pin Male
J4	Analog TM	311P405-4S-C-12	37 Pin Female
J5	Clock	311P405-1P-C-12	9 Pin Male
J6	Data Processor	311P405-2P-C-12	15 Pin Male
J7	Test	311P405-5S-C-12	50 Pin Female
J33	Pulse Load Heater	311P405-1S-C-12	9 Pin Female

18.1.2.8.1 Power Input

18.1.2.8.1.1 General – The +28V DC input from the spacecraft is regulated to obtain isolat[illegible] from spacecraft voltage variations, converted to develop a system ground, and re-regul[illegible] obtain noise rejection and precision.

18.1.2.8.1.2 Electronics Switching Regulator – Two input switching regulators are provided using Harris HA2620 amplifiers as comparators: The circuits are self starting and driven by 62.[illegible] KH[illegible] signal for synchronization with the spacecraft clock. A +34V boost voltage derived from th[illegible] P[illegible] Converter provides the drive voltage for the pass transistor to provide good saturation f[illegible] dissipation.

18.1.2.8-1 .3 Power Converter – Two DC/DC Converters are provided, one powered from e[illegible] Switching Regulator. These circuits establish signal ground for the AVHRR and provide the proper voltage inputs to the electronics regulators. They are driven converters being synchronized w[illegible] the same 62.4 KHz clock signal as the switching regulators.

18.1.2.8.1.4 +5V Regulators – A switching regulator is used to provide +5 volts for lo[illegible] circuits The output of the switching regulator directly feeds the logic circuits required for mot[illegible] frequenc[illegible] countdown and the input clock circuits. The major portion of the logics is powered through a switching transistor from the regulator output. This transistor is turned on with the Electron[illegible] ON command.

18.1.2.8.1.5 ±15V Regulators – The 15 volt regulators are linear circuits utilizing the Harris HA2620 I.C. as the voltage comparator. The +15 volt regulator uses a +20 volt "boost" voltage from the power converter to enable a low input/output differential and minimize the p[illegible] [illegible] power loss. The circuit will regulate under full load with an input/output differential equal to the collector/emitter saturation voltage of the pass transistor which is typically 0.2 volt.

18.1.2.8.1 .6 Power Profile – Table 18.1–10 depicts the power usage under the mode of operation indicated.

Table 18.1-10 Power Profile

Function	Power	Normal Operation	Telemetry Only	Motor On	Cooler Heater	Instrument Off
Analog Telemetry & Logics	3.22W	X	X	X	X	
A-D & Electronics	12.94W	X				
Scan Motor High	4.84W	X		X		
Scan Motor Low	3.98W			X		
Channel 1	0.67W	X				
Channel 2	0.89W	X				
Channel 3	1.4 w	X				
Channel 4	0.95W	X				
Channel 5	1.8 W	X				
Cooler Heater	21.2 w				X	
Cooler Cover Deploy	56.9 w*					
Standby Heater	22.8W**					X
	.	26.71W	3.22W	7.20 or 8.06	24.75W	22.8W**

* Required only once for a period of approximately 1 sec.
**Supplied from TCE – not from +28V buss.

18.1.2.8.2 Commands

The spacecraft will provide the command inputs listed below to the AVHRR. The general characteristics of these commands are detailed in Section 3.1.4.2 of the General Instrument Interface Specification.

For “Level” commands, the “On”, “True”, or “Low” level is indicated by a logic “1” or a zero volt level. The “Off”, “False”, or “High” level is indicated by a Logic “0” or +10 volt level for CMOS logic.

The AVHRR commands can be further classified as Power or Mode Commands. The function of each command is detailed in the following paragraphs.

18.1.2.8.2.1 Power Commands [S/C MNEMONIC]

[ASMTN] (1) Scan Motor/Telemetry ON

This command shall turn ON the scan motor, scan drive electronics, and the first of 3 parallel power switches for housekeeping telemetry specifically, this command applies power to

a) Electronics sw. regulator
b) Motor sw. regulator
c) Power converter
d) ±15V regulators
e) +5V motor logic reg.
f) Clock receiver
g) Motor logic
h) Analog telemetry circuits
i) Patch temp. control

[ASMTF] (2) Scan Motor/Telemetry OFF

This command shall turn OFF the scan motor, scan drive electronics, and the first of 3 parallel power switches for housekeeping telemetry.

[AELTN] (3) Electronics/Telemetry ON

This command shall turn ON the radiometer electronics (except the scan drive electronics) for all channels in the ENABLE mode and the second of 3 parallel power switches for housekeeping telemetry. Specifically, this command applies power to:

a) Electronics sw. regulator
b) Power converter
c) ±15V regulators
d) +5V motor logic regulator
e) +5V electronics regulator
f) Analog telemetry circuits
g) A/D converter
h) Scan timing logic
i) Clock receiver
j) Motor logic
k) Patch temp. control

[AELTF] (4) Electronics/Telemetry OFF

This command shall turn OFF the radiometer electronics and the second of 3 parallel power switches for housekeeping telemetry.

[ACH1E] (5) Channel 1 Enable

If "Electronics On" has been executed – Applies Power to:

a) Ch 1 Preamplifier
b) Ch 1 Postamplifier

[ACH1D] (6) Channel 1 Disable

Removes power from:

a) Channel 1 Preamplifier
b) Channel 1 Postamplifier

[ACH2E] (7) Channel 2 Enable

If "Electronics On" has been executed –
Applies Power to:

a) Ch 2 Preamplifier
b) Ch 2 Postamplitier

[ACH2D] (8) Channel 2 Disable

Removes power from:

a) Channel 2 Preamplifier
b) Channel 2 Postamplifier

[ACH3E] (9) Channel 3 Enable (11μ)

If "Electronics On" has been executed – Applies Power to:

a) Ch 3 Preamplifier
b) Ch 3 Postamplifier

[ACH3D] (10) Channel 3 Disable (11μ)

Removes power from:

a) Channel 3 Preamplifier
b) Channel 3 Postamplifier

[ACH4E] (11) Channel 4 Enable (3.7~)

If "Electronics On" has been executed –
Applies power to:

a) Ch 4 Preamplifier
b) Ch 4 Postamplifier

[ACH4D] (12) Channel 4 Disable (3.7~)

Removes power from:

a) Channel 4 Preamplifier
b) Channel 4 Postamplifier

[ACHON] (13) Cooler Heat On

If "Electronics On", "Motor On" or "Telemetry On" has been executed – Applies power to:

a) Radiator Decontamination Heater
b) Patch Decontamination Heater

[ACHOF] (14) Cooler Heat Off

Removes power from :

a) Radiator Decontamination Heater
b) Patch Decontamination Heater

[ATLON] (15) Telemetry Locked On

This command shall turn on the third of 3 parallel power switches for Housekeeping Telemetry, thereby locking the telemetry on independent of Commands 1 through 4. Specifically, this command applies power to:

a) Electronics sw. regulator
b) Power converter
c) ±15V regulators
d) +5V Motor Logic Regulator
e) Clock Receiver
f) Motor Logic
g) Analog Telemetry Circuits
h) Patch control circuitry

[ATNLO] (16) Telemetry Not Locked On

This command shall turn off the third of 3 parallel power switches for Housekeeping Telemetry thereby returning the telemetry to the control of Commands 1 through 4.

[AESDP] (17) Earth Shield Deploy

Applies power to:

a) Earth Shield Circuitry

[AESDII (18) Earth Shield Disable

Removes power from :

a) Earth Shield Circuitry

[APCON] (19) Patch Control On

If "Telemetry On" has been executed –
Applies controlled heat to

a) Patch

[APCOF] (20) Patch Control Off

Removes heat from patch

[ACH5E] (21) *Channel 5 Enable

If "Electronics On" has been executed –
Applies power to:

a) Ch 5 Preamplifier
b) Ch 5 Postamplifier

[ACH5D] (22) *Channel 5 Disable

Removes power from :

a) Channel 5 Preamplifier
b) Channel 5 Postamplifier

18.1.2.8.2.1.2 Mode Commands

[AVCONI (23) Voltage Calibrate On

If "Electronics On" and "Motor On" have been executed –

a) Deactivates IR & Daylight detectors.
b) Provides simulated earth scene and backscan video for all enabled channels.

*Not used on AVHRR/1

[AVCOF] (24) Voltage Calibrate Off

If "Electronics On" and "Motor On" have been executed –

a) Activates IR & Daylight detectors.
b) Deactivates simulated earth scene & backscan video,

[APCHM] (25) Patch Control High Mode

If "Telemetry On" has been executed –

a) Sets patch temp. control point to 108 °K for AVHRR/2.

[APCLM] (26) Patch Control Low Mode

If 'Telemetry On" has been executed –

a) Sets patch temp. control point to 105°K.

[ASMHM] (27) Scan Motor High Mode

If "Motor On" has been executed –

a) Sets motor sw. regulator voltage to HIGH LEVEL,

[ASMLM] (28) Scan Motor Low Mode

If "Motor On" has been executed –

a) Sets motor sw. regulator voltage to LOW LEVEL

18.1.2.8.3 <u>MIRP Processing of AVHRR Data</u>

This section is provided as an overview of the AVHRR/2 data processing that takes place in the Spacecraft Manipulated Information Rate Processor (MIRP). The MIRP sends data sample pulse to the AVHRR/2 digital output timing logic which results in the sequential transfer of a data word for each radiometric channel. The MIRP processes these data into the following four outputs.

18.1.2.8.3.1 <u>Automatic Picture Transmission (APT)</u> — Any two of the five AVHRR/2 channels can be command-selected for processing. This data undergoes the following

(a) Resolution reduction by utilizing only one out of every three scans and averaging the data within the line over an area equivalent to approximately four Field-of-View's (FOV's) at nadir.

(b) Geometric correction by the averaging algorithm which effectively translates the data in time so that each sample represents approximately 2 nmi of sweep on the Earth's surface. This translation reduces the perspective effect due to the Earth's curvature and the satellite altitude.

(c) Digital to Analog – The digitally processed APT data are converted to a 2080-Hz bandwidth analog signal, amplitude modulated onto a 2.4-kHz carrier, and bandwidth limited to 4 160 Hz in preparation for transmission by the VHF transmitters.

18.1.2.8.3.2 Global Area Coverage (GAC) – MIRP produces the GAC output by combining processed AVHRR data with the TIP data. The GAC frame rate is 2 frames per sec; that is, it is one third of the AVHRR scan rate. The GAC processing of the AVHRR data makes the frame rates directly compatible by only using the data from every third AVHRR scan. The MIRP further reduces the data by producing only one output sample for each five input samples. The TIP word and frame rate is directly compatible with the GAC word and frame rate; five TIP minor frames are inserted (at 0.1 sec per frame) into the GAC frame each 0.5 sec. Two parity bits are added to the 8-bit TIP word to form the 10-bit MIRP word. The GAC output is supplied only to the spacecraft DTR Input Selector Unit of the XSU, and it is, therefore, only available for the transmission from the tape recorders.

18.1.2.8.3.3 High Resolution Picture Transmission (HRPT) – MIRP produces the HRPT and the LAC outputs by combining unprocessed AVHRR data with TIP data. The basic frame rate and data rate of the HRPT is compatible with the AVHRR. Therefore, only buffering is required to construct the HRPT frame from the AVHRR data. However, since the TIP frame rate is only one third that required to fill the HRPT frame, the TIP data must be repeated three times. This is accomplished by repeating the five TIP minor frames (104 words each) in each of three HRPT frames. As in GAC, two parity bits are added to the 8-bit TIP word to form the 10-bit MIRP word. The HRPT output is supplied to the S-band transmitter input control for real-time transmission.

18.1.2.8.3.4 Local Area Coverage (LAC) – LAC is, by definition, recorded HRPT; thus, the LAC output is supplied only to the spacecraft DTR input selector for recording.

18.1.3 ACTIVATION SEQUENCE

18.1.3.1 AVHRR, 30°C Radiant Cooler

The activation sequence for the AVHRR/2 (S/N 203, S/N 205, S/N 206) instruments with a 30 °C radiant cooler decontamination heater is as follows:

(a) Commands Prior to Launch – Scan Motor/Telemetry On (ASMTN), Scan Motor High Mode (ASMHM), and Telemetry Locked On (ATLON).

(b) Gilmore 1 Commands-- Electronics/Telemetry On (AELTN), repeat Telemetry Locked On (ATLON), and Cooler Heat On (ACHON).

(c) Gilmore 3 Commands- Channel 1 Enable (ACH1E) and Channel 2 Enable (ACH2E).

(d) Wallops 202 or 216 Commands – Command spacecraft 28 volt 'bus current, analog telemetry channel 296, into 1 second dwell mode prior to Earth Shield Deploy (AESDP), wait until the telemetry confirms that the door is open and send Earth Shield Disable (AESDI), Cooler Heat Off (ACHOF), Patch Control Low Mode (APCLM), Patch Control On (APCON), and command spacecraft 28 volt bus current 1 second dwell mode off.

(e) Wallops 217 or 230 Commands – Channel 3 Enable (ACH3E), Channel 4 **Enable** (ACH4E), and Channel 5 Enable (ACH5E).

18.1.4 CONSTRAINTS

18.1.4.1 General

The various modes of operation have specific requirements (constraints) that must be met, either prior to initiation of a mode or after it has been established. Constraints imposed for the various operating modes are listed in the following paragraphs.

18.1.4.2 Prelaunch Mode

(a) The cooler door must be verified latched.

(b) Cooler and scan cavity dust covers must remain in place for testing.

(c) All command relays must be verified in prelaunch (off) configuration prior to putting the AVHRR/2 into launch configuration.

(d) Baseplate temperature limits, during all modes, is 10 to 30°C.

(e) The decontamination heater system for the radiant cooler is a thermostatically controlled system, originally designed to limit radiant cooler temperature to a maximum of 30°C. This is consistent with the requirement that the HgCdTe detectors be kept below 30 °C.

Special precautions must therefore be taken when operating the cooler heater in testing these instruments to avoid detector temperatures in excess of 30°C *because of a possible detector performance degradation or failure.*

18.1.4.3 Launch Mode

(a) Verify that dust covers are removed prior to launch.

(b) For launch the scan motor must be operating in the High Mode.

(c) See activation sequence 18.1.3.

18.1.4.4 Orbit Mode Constraints

The cooler door opening mechanism has a time-out device which automatically disables the solenoid after the door has opened. For safety, however, the cover release DISABLE command should be transmitted after positive indication has been received that the door is open.

18.2 HIGH RESOLUTION INFRARED RADIATION SOUNDER (HIRS/2)

18.2.1 GENERAL

The High Resolution Infrared Radiation Sounder (HIRS/2I) is a discrete stepping, line-scan instrument designed to measure scene radiance in 20 spectral bands to permit the calculation of the vertical temperature profile from Earth's surface to about 40 km.

Multispectral data from one visible channel (0.69 micron), seven shortwave channels (3.7 to 4.6 micron) and twelve longwave channels (6.7 to 15 micron) are obtained from a single telescope and a rotating filter wheel containing twenty individual filters. A mirror provides cross-track scanning of 56 increments of 1.8°. The mirror steps rapidly, then holds at each position while the filter segments are sampled. This action takes place each 0.1 seconds. The instantaneous field of view for each channel is approximately 1.2" which, from an altitude of 833 kilometers, is an area 17.45 kilometer diameter at nadir on the earth.

Three detectors are used to sense the radiation. A silicon cell detects the energy through the visible filter. An Indium Antimonide detector and a Mercury Cadmium Telluride detector mounted on a passive radiator and operating at 105K sense the shortwave and longwave infrared energy. The silicon cell works at ambient temperature. The shortwave and visible detectors share a common field stop, while the longwave uses a separate but identical field stop. Registration of the fields in all channels are determined by these field stops with a secondary effect from detector position.

Calibration of the HIRS/2I infrared channels is provided by programmed views of three radiometric targets, a warm target mounted to the instrument base, a cold target isolated from the instrument and operating at near 265K, and a view of space. Data from these views provide sensitivity calibrations for each channel at 256 second intervals if so desired. Internal electronic signals provide calibration of the amplifier chains at 6.4 second intervals.

Data from the instrument is multiplexed into a single data stream controlled by the TIP system of the spacecraft. Information from the radiometric channels and voltage telemetry are converted to 13-bit binary data. Radiometric information is processed to produce the maximum dynamic range such that instrument and digitizing noises are a small portion of the signal output. Each channel is characterized by a noise equivalent radiance (NEAN) and a set of calibration data that may be used to infer atmospheric temperatures and probable errors.

The HIRS/2I instrument is a single package mounted on the Instrument Mounting Platform (IMP) of the TIROS-N series of spacecraft. A thermal blanket encloses most outer surfaces other than that of the radiating panel and door area. The radiating surface views space, emitting its heat to provide passive cooling of the detectors to the 105K temperature. An earth shield prevents thermal input from that direction, and is part of a door assembly that is closed during launch and for an initial outgas period. The door is opened at the end of that period, providing cooling. If indications of contamination occur the door remains open and heat is applied to bring both stages of the radiative cooler to near 300K.

Table 18.2-l lists the general characteristics of the HIRS/2I Instrument. Table 18.2-2 lists the spectral channels and sensitivity requirement for the HIRS/2I. Figure 18.2-1 provides the scanning pattern of the scan mirror and the positions of the calibration targets relative to earth-scan.

Table 18.2-1 HIRS/2 System Characteristics

Optical Field of View	1.22” all channels
Including Energy	97% within 1.80”
Channel to Channel Registration	1% of total FOV
Earth Scan Angle	99.0”
Earth Scan Steps	5 6
Step and Dwell Time	100 ms total
Total Scan plus Retrace Time	6.4 s
Earth Swath Coverage	1127km
Earth Field Coverage	17.5 km (1.22 FOV)
Radiometric Calibration	290K Black Body, 265K Black Body, and Space Look
Frequency of Rad. Cal.	256 s, typical
Dwell Time at Cal Positions	5.6 s (4.85 at space)
Longwave Channels	12
Longwave Detector	Mercury Cadmium Telluride
Shortwave Channels	7
Shortwave Detector	Indium Antimonide
Visible Channel	1
Visible Detector	Silicon
Signal Quantizing Levels	8192 (13–bit coding) ±4096 12–bit + sign
Electronic Calibration	32 equal levels each polarity
Frequency of Elect_ Cal.	One level each scan line (6.4 s)
Telescope Aperture	15.0 cm (5.9 in)
Detector Temperature	105K
Filter Temperature	303K

Table 18.2-2 HIRS/2I Spectral Requirements

Channel	Channel Frequency (cm^{-1})	μm	Half Power Bandwidth (cm^{-1})	NEAN (Spec.)	NEAN (Goal)
1	669	14.95	3	3.00	0.75
2	680	14.71	10	0.67	0.25
3	690	14.49	12	0.50	0.25
4	703	14.22	16	0.31	0.20
5	716	13.97	16	0.21	0.20
6	733	13.64	16	0.24	0.20
7	749	13.35	16	0.20	0.20
8	900	11.11	35	0.10	0.10
9	1,030	9.71	25	0.15	0.15
10	797	12.55	16	0.20	0.15
11	1,365	7.33	40	0.20	0.20
12	1,488	6.72	80	0.19	0.10
13	2,190	4.57	23	0.006	0.002
14	2,210	4.52	23	0.003	0.002
15	2,240	4.46	23	0.004	0.002
16	2,270	4.40	23	0.002	0.002
17	2,420	4.13	28	0.002	0.002
18	2,515	4.00	35	0.002	0.002
19	2,660	3.76	100	0.001	0.001
20	14,500	0.69	1000	0.1%	0.10%A

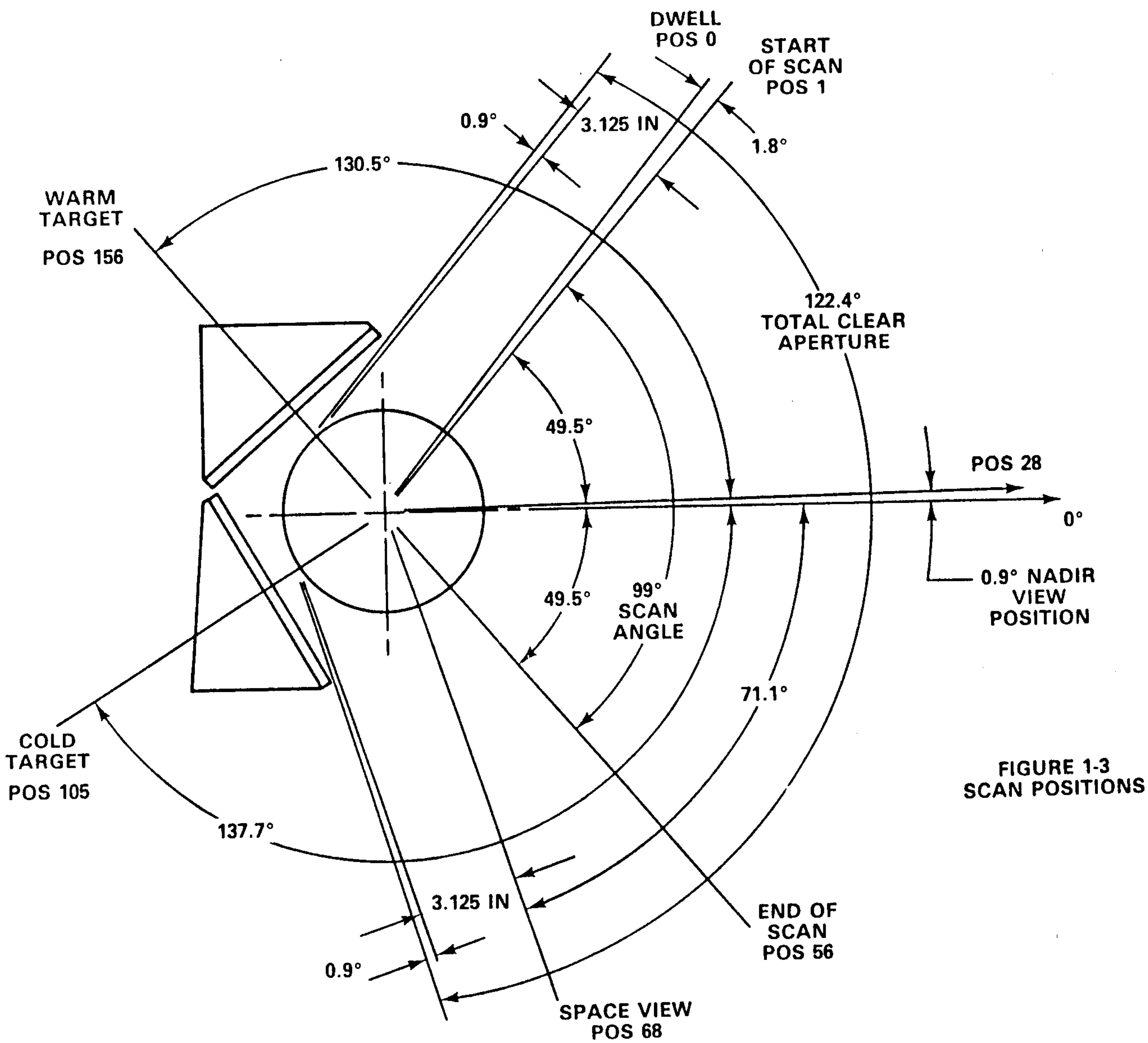


Figure 18.2-1. Scan positions.

18.2.2 SYSTEM DESCRIPTION

18.2.2.1 Introduction

The HIRS/2I is a 20-channel scanning radiometric sounder utilizing a stepping mirror to accomplish cross-track scanning, directing the radiant energy from the earth to a single, 6-inch diameter telescope assembly every tenth of a second. Collected energy is separated by a beam-splitter into Iongwave (above 6.5 μm) and shortwave (visible to 4.6 μm), passed through field stops and through a rotating filter wheel to cooled detectors. In the shortwave path a second beamsplitter separates the visible channel to a silicon detector.

The scan logic and control set the sequence of earth viewing steps to provide a rapid scan mirror step motion to 56 fixed positions for spectral sampling of each respective air column. The filter wheel rotation is synchronized to this step and hold sequence, with approximately one-third of the wheel blank to accommodate each step interval and with the filters positioned for sampling only after the mirror has reached the hold position. Registration of the optical fields for each channel to a given column of air is dependent to some degree on spacecraft motion and on the alignment of two field stops, which can be adjusted to less than 1 percent of the field diameter.

Radiant energy is focused on cooled detectors operating at a near optimum temperature of 105K. A Mercury Cadmium Telluride detector and Indium Antimonide detector are mounted on a two-stage radiant cooler. This assembly is large enough to have reserve cooling capacity, permitting active thermal control to maintain the detectors at a fixed 105K. A system of heating the patch and first stage is provided for initial outgassing and for decontamination later if it should be desired.

Electronic circuits provide the functions of power conversion, command, telemetry, and signal processing. Amplification of the inherently weak signals from the detector:, is done in low noise amplifiers. Radiant signals are fed through a base reference and memo.-, processor, multiplexed, and A/D converted by a 13-bit range system. Once converted to a dig, l format, the data are again multiplexed with HIRS/2I "housekeeping" data and providerj as serial data stream at the digital A output. Data from HIRS/2I are held in memory until ... the TIROS Information Processor (TIP) request signals and clocked out of the instru... by ... TIP clock. A simplified diagram of the HIRS/2I system is in Figure 18.2-2

Repetitive inclusion of electronic calibration signals and the periodic comma... at space and two internal blackbodies provide the system with a complete set of data co... or ca... bration, and control that should permit reliable operation in orbit.

General characteristics of the HIRS/2I instrument are better understood through stud,; of Figure 18.2-2 for electrical functions and Figure 18.2-3 which shows the major subassemblies of the instrument in an exploded view.

The characteristics of the instrument temperature sensors are shown in Table 18.2- where it may be noted that calibration sources are measured very precisely. Table 18.2-4 is a typical printout of the HIRS/2I test equipment during a system test.

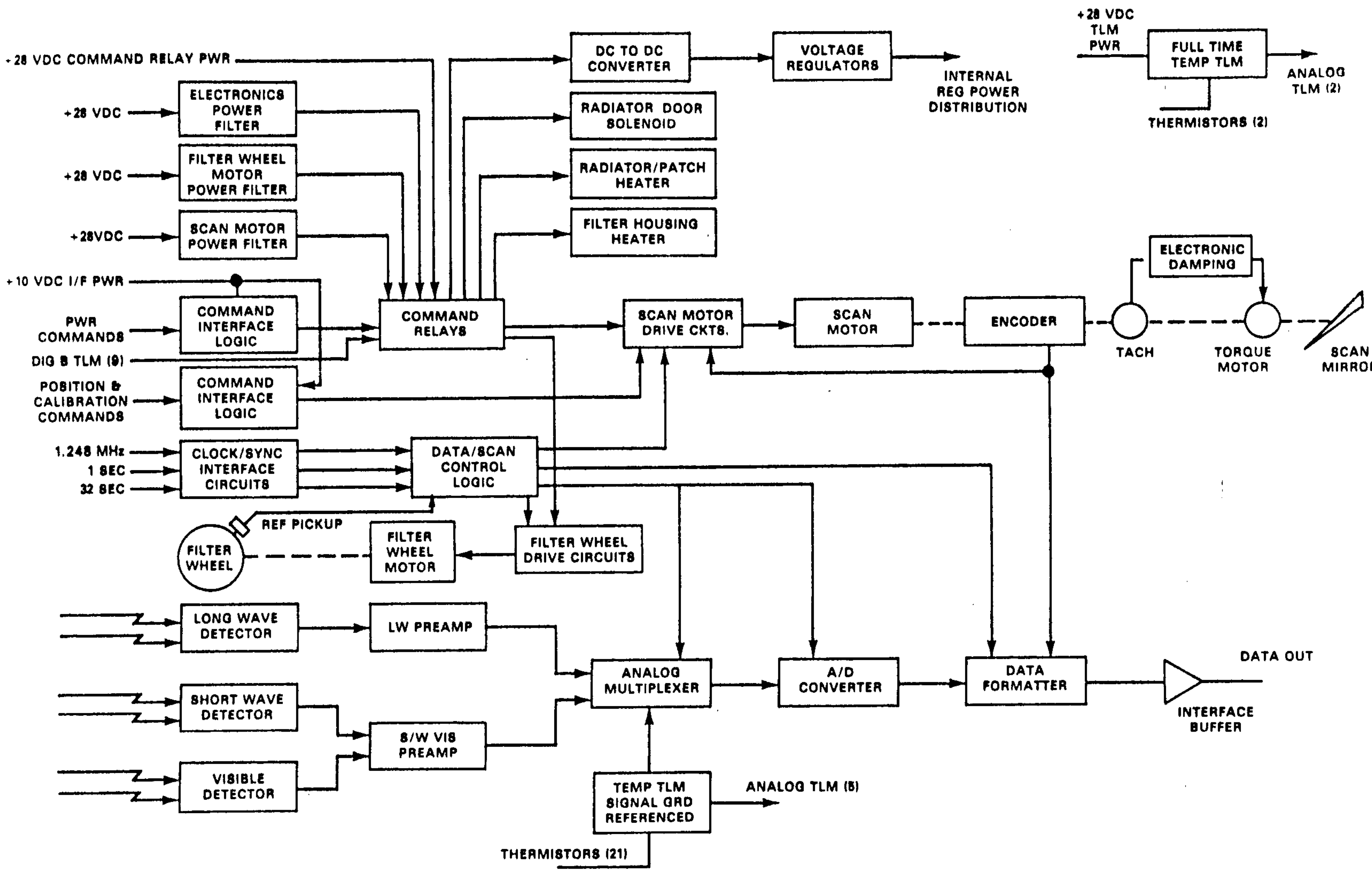


Figure 18.2-2. HIRS/2I system block diagram.

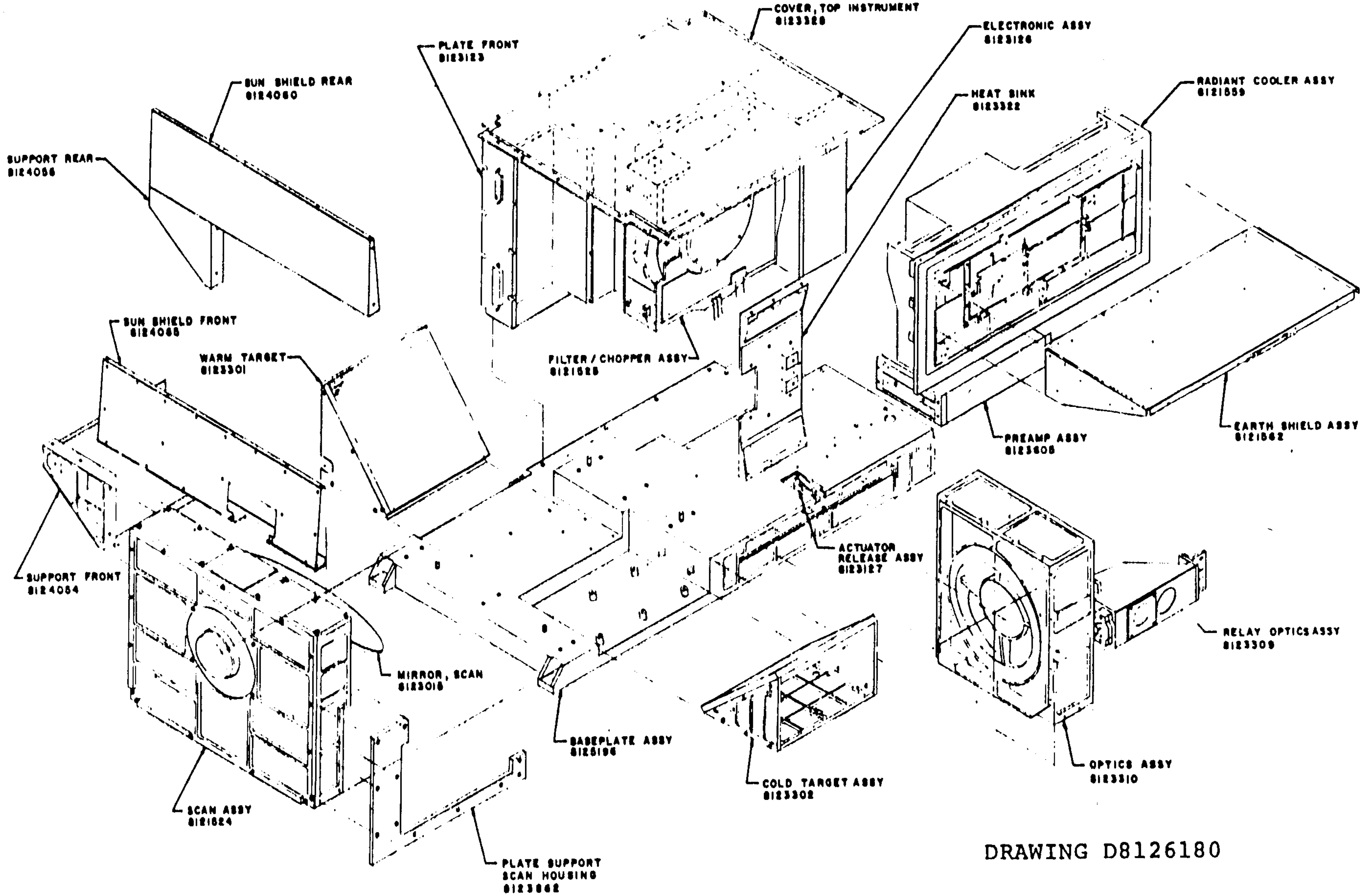


Figure 18.2-3. HIRS/2I system subassemblies.

Table 18.2-3 Sensor Temperature Ranges

Sensor Location	Subcomm Analog (°K)	Digital "A" (°K)	Approximate Digital A Sensitivity Counts/°K	Nominal @ Operating Temperature
Patch – full range	90 – 320	90 – 320	53	@ 105K
– expanded range		90 – 150	141	@ 105K
Radiator	150-320	150 – 320	60	@ 170K
F/W Motor	260 – 320	260 – 320	71	@ 300K
Scan Motor	*260 – 320	260 – 320	78	@ 295K
Baseplate	*260 – 320	260 – 320	78	@ 290K
Electronics	260 – 320	260 – 320	78	@ 290K
Primary Mirror		260 – 320	78	@ 290K
Secondary Mirror		260 – 320	78	@ 290K
Scan Mirror		260 – 320	78	@ 290K
F/W Housing -1		273.15K – 333.15K		
-2		273.15K – 333.15K	152	@ 303K
-3		273.15K – 333.15K		
-4		273.15K – 333.15K		
Internal Warm Target -1		273.15K – 333.15K		
-2		273.15K – 333.15K	152	@ 290K
-3		273.15K – 333.15K		
-4		273.15K – 333.15K		
Internal Cold Target -1		243.15K – 303.15K		
-2		243.15K – 303.15K	152	@ 273K
-3		243.15K – 303.15K		
-4		243.15K – 303.15K		

*Housekeeping TLM (full time temp. monitoring on switched +28 VDC TLM BUSS).

Table 18.2-4 Typical Digital A Telemetry

Instrument Temperatures				
Place	Counts	Volts	Temp. (C)	Temp. (K)
IWT 1	-2099.00	-2.564	14.40	287.64
IWT 2	-2111.00	-2.578	14.40	287.55
IWT 3	-2120.20	-2.589	14.35	287.50
IWT 4	-2104.00	-2.570	14.43	287.58
ICT 1	-503.60	-0.615	-4.77	268.38
ICT 2	-354.80	-0.433	-3.88	269.27
ICT 3	-364.40	-0.445	-3.95	269.20
ICT 4	-436.00	-0.532	-4.37	268.18
FW HSG 1	239.00	0.292	29.88	303.03
FW HSG 2	3 13.00~	0.382	30.26	303.4:
FW HSG 3	195.00	0.238	29.55	302.70
FW HSG 4	308.00	0.376	30.28	303.43
PATCH EXP	- 1500.60	- 1.833	-166.56	106.59
RAD COOLER	2627 .OO	3.208	- 102.43	170.[illegible]
SCAN MIRROR	1898.00	2.318	13.35	286.50
PRI TELESCOPE	1914.00	2.338	13.56	286.71
SEC TELESCOPE	2044.00	2.496	15.23	288.38
HIRS BASE	1985.00	2.428	14.48	287.63
HIRS ELECT	2209.00	2.698	17.3 1	290.48
HIRS PATCH	3119.00	3.809	-166.53	106.62
SCAN MOTOR	2 137.00	2.610	16.44	289.5’
FILT WH MOTOR	3008 .OO	3.674	28.07	301.[illegible]

Instrument Voltages and Currents			
Place	Counts	Value	
F/W Housing HTR	1329.40	0.162	AMP
ELECT CAL	-2664.60	-3.254	VOLT
ANALOG GRD	0.00		
PATCH CONT PWR	1295.00	8.085	MILLIWATT
SCAN MOTOR	1746.00	0.853	AMP
FW MOTOR CNT	1696.00	0.207	AMP
+15 VDC	3062.00	14.958	VOLT
-15 VDC	-3064.00	- 14.968	VOLT
+7.5 VDC	3038.00	7.42 1	VOLT
-7.5 VDC	-3046.00	-7.440	VOLT
+10 VDC	3256.00	9.941	VOLT
+5 VDC	30 17.00	4.913	VOLT
ANALOG GRD	0.00		
ANALOG GRD	0.00		

18.2.2.2 Instrument Interfaces

The instrument interfaces consist of power, command, telemetry data systems. The data are controlled and directed through the Tiios Information Processor (TIP). All electrical connections to the HIRS/2I are made through the connectors listed in Table 18.2-5. A test connector is provided for use in subsystem and system test at the instrument level. This connector (J7) is capped and not used in spacecraft testing or operation. The requirements of the General Instrument Interface Specification (GIIS) IS-2280259 are followed in the connection, operation and control of interfaces to the spacecraft.

18.2.2.2.1 Power Input — The HIRS/2I instrument is powered from the Spacecraft +28 volt main buss, a + 28 volt pulse load buss; a switched + 28 volt analog telemetry buss and a + 10 volt interface buss. A separate input provides power to the base heater from the spacecraft Temperature Control Electronics (TCE) system.

All power systems are brought to the HIRS/2I system on separate leads. The power source-s remain separate within the instrument, with returns maintained separate for each supply. A single chassis ground is brought to the output connector on an isolated pin. Signal and power grounds remain separate. A capacitive connection was made between signal ground and the chassis at the radiant cooler to reduce noise in the longwave preamp.

The distribution of power is shown in Figure 18.24. It may be noted that Instrument Power command is the primary control of power to the system. With this power switched on there is power only to the telemetry dc-dc converter, providing output from analog telemetry as well as digital B telemetry even when other instrument functions are not turned on.

Table 18.2-5 HIRS/2I Interface Connector Types

Connector No.	Function	Style	Type
J1	Clock	9 Pin Male	GSFC 311P405-1P-C-12
J2	Power	25 Pin Male	GSFC 311P405-3P-C-12
J3	Command	37 Pin Male	GSFC 311P405-4P-C-12
J4	Analog TLM	37 Pin Female	GSFC 311P405-4S-C-12
J5	Digital TLM	25 Pin Female	GSFC 311P405-3S-C-12
J6	Data	15 Pin Male	GSFC 311P405-2P-C-12
J7	Test	50 Pin Female	GSFC 311P405-5S-C-12
J8	HTR	9 Pin Female	GSFC 311P405-1S-C-12

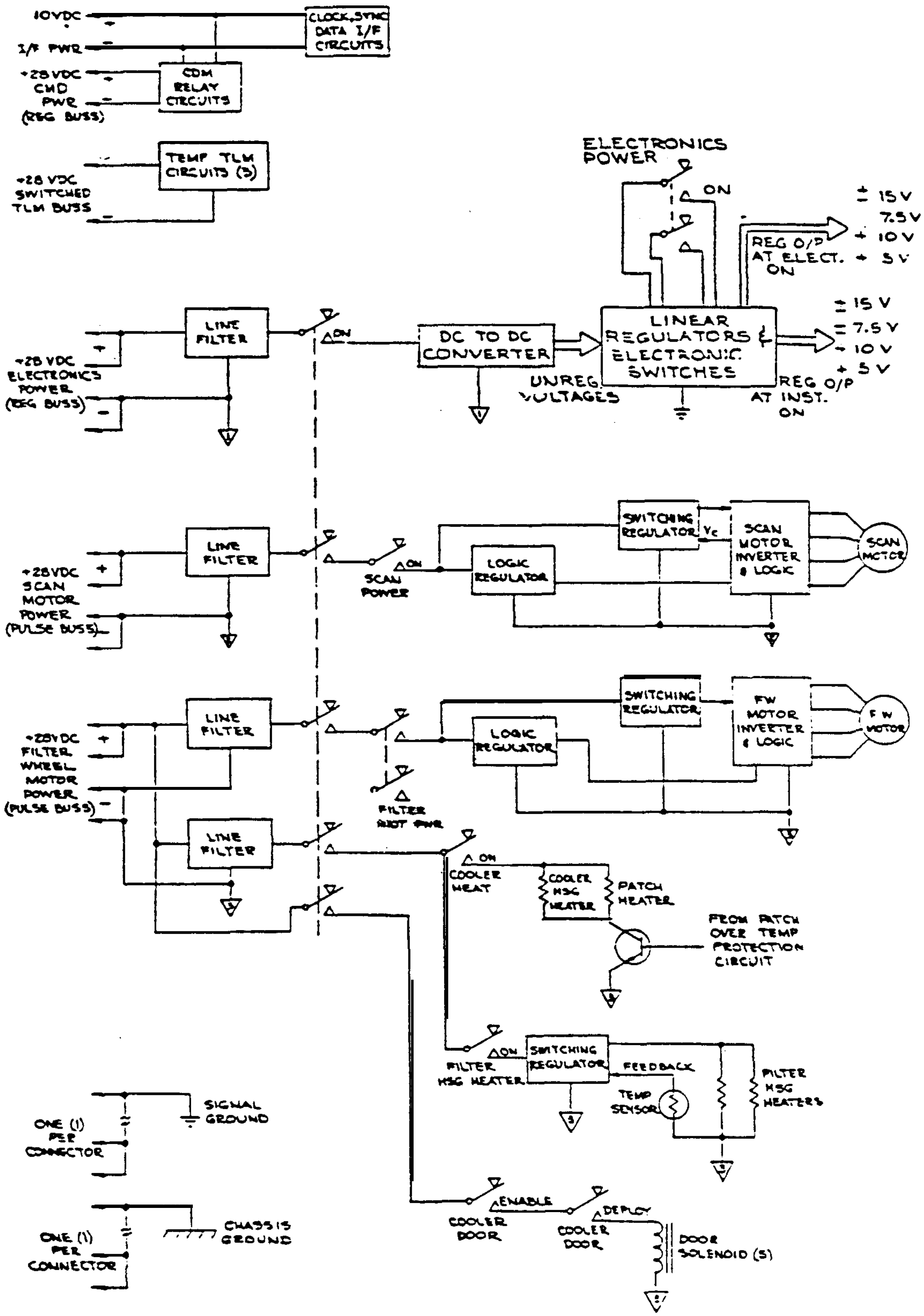


Figure 18.24. HIRS/2I power distribution.

With Instrument Power ON, any combination of subsystem power may be applied. This permits the operation of the scan motor, filter motor, filter housing heater and door deployment independent of system electronics such that combinations of functions may be selected for launch, decontamination, standby or other operating conditions.

The power required for system operation is obtained from all the above sources. In normal operating (mission) mode the average power demand is as shown in Table 18.2-6.

Table 18.2-6 HIRS/2 Power Demand (Mission Mode)

+28V Regulated	8.1 watts
+28V Pulse, Scan	8.2
, F.W.	6.4
+10V Interface	0.1
+28V Command	0
+28V Telemetry	.03
Base Heater	0
Total Average *	22.8

*Similar for HIRS/2I

Peak current demands occur periodically during the scan cycle for short durations. At that time the power demand may reach 27.5 watts.

During system outgas an additional 28 watts for HIRS/2I may be required to maintain the cooler components at their prescribed temperatures. When the cooler door is closed at initial outgas this peak load is intermittent, adding only 5 watts to the average load.

18.2.2.2.2 Commands — The commands to the HIRS/2I instrument are all pulse commands, activating relays or directly controlling a circuit element. The commands are listed in Table 18.2-7.

One feature of the HIRS/2I instrument is the automatic reset of many of the commands when Instrument OFF is received. Commands 1-19 will reset to the OFF condition at that time. This ensures that when the instrument is turned on again that the system will be in a defined condition, assuring a low power condition and providing a basis for a consistent turn-on sequence.

Table 18.2-7 HIRS/2I Commands

No.	Command [S/C MNEMONIC]	Description
1.	Instrument ON [H2PON]	This command connects both the +28 electronics bus and pulse bus to HIRS/2 and energizes the DC/DC converter, permitting subcomm analog temperature monitoring in the absence of all other power.
2.	Instrument OFF [H2POF]	Disconnects all +28V busses from the instrument except +28V bus for commands and full time +28V telemetry bus. It returns all other commands to OFF or disabled condition except as noted (see 18.2.4.2).
3.	Scan Motor ON [H2SMN]	Provides power to the scan motor. When used with electronics off, it drives scan motor in a continuous stepping mode, This feature is ssed during launch to prevent damage to motor bearings
4.	Scan Motor OFF [H2SMF]	Command scan motor off.
5.	Filter Wheel Motor ON [H2FWN]	Provides power to the Filter Wheel drive motor. Permits filter wheel operation near synchronous speed when electronics power is off.
6.	Filter Wheel Motor OFF [H2FWF]	Commands filter wheel motor off.
7.	Electronics ON [H2ELN]	Provides power to all remaining electronic and data handling systems
8.	Electronics OFF [H2ELF]	Commands electronics power off.
9.	Cooler Heat On [H2CHN]	Provides power to first and second stage cooler heaters. Used during orbital decontamination.
10.	Cooler Heat OFF [H2CHF]	Commands cooler heater power off.

Table 18.2-7. HIRS/2I Commands (continued)

No.	Command [S/C MNEMONIC1	Description
11.	Internal Warm Target (IWT) Position [H2IWT]	When the instrumentis in the calibration enable mode this command causes the scan mirror to move to the internal warm target after completion of the current scan line and retrace to step zero. The scan mirror will remain at the IWT until this command is disabled by Position Disable (see 18.2.4.2).
12.	Internal Cold Target (ICT) Position [H2ICT]	When the instrument is in the calibration enable mode this command causes the scan mirror to move to the internal cold target after completion of the current scan line and retrace to step zero. The scan mirror will remain at the ICT until this command is disabled by Position Disable.
13.	Space Position [H2SPA]	When the instrument is in the calibration enable mode this command causes the scan mirror to move to space after completion of the current scan line and retrace to step zero. The scan mirror will remain at space until this command is disabled by Position Disable.
14.	Nadir Position [H2NAD]	When the instrument is in the calibration enable mode this command causes the scan mirror to move to nadir after completion of the current scan line and retrace to step zero. The scan mirror will remain at nadir until this command is disabled by Position Disable.
15.	Position Disable [H2PDA]	Disables the IW'T, ICT, Space and Nadir position commands and returns scan mirror to scan step 0. Scan will resume upon receipt of next line sync (first element) pulse.
16.	Calibration Enable [H2CLE]	Enables the radiometric calibration control logic. When sent, the scanner will continue line scanning until the next major frame sync pulse. It will then execute a normal calibration sequence. Subsequent calibration sequence will be executed upon receipt of a Calibration Start Pulse (as described in Section 18.2.2.2.3) coincident with major frame sync.
17.	Calibration Disable [H2CLD]	Disable the instrument calibration mode. In this mode the instrument will ignore the spacecraft calibration start pulse.

Table 18.2-7 HIRS/2I Commands (continued)

No.	Command [S/C MNEMONIC]	Description
18.	Cover Release Enable [H2CRE]	Provides power to the earth shield release solenoid drive circuit only after Instrument Power is ON.
19.	Cover Release Disable [H2CRD]	Reset the Cover Release Enable relay to the OFF position.
20.	Cooler Cover Deploy [H2CCD]	Commands opening of cooler door by applying a two second pulse to the cover release solenoid. Operates only if Instrument Power On and Cover Release Enable commands are sent.
The following commands will not be affected by the instrument off command.		
21.	Filter Housing Heat ON [H2FHN]	Provides power to filter housing heaters and automatic temperature control circuitry.
22.	Filter Housing Heat OFF [H2FHF]	Commands filter housing heat off.
23.	Patch Temp. Control ON [H2PCN]	Provides power to patch temperature control heater to control patch at approximately 107°K.
24.	Patch Temp. Control OFF [H2PCF]	Commands patch temp. heater off permitting patch to seek equilibrium temperature.
25.	Filter Motor Normal Power [H2FMN]	Applies preset power level to filter wheel motor for normal operation.
26.	Filter Motor High Power [H2FMH]	Applies maximum power to filter wheel motor for cold operation and end of life conditions.

18.2.2.2.3 Timing Signal Inputs — The HIRS/2I system is controlled by the spacecraft I.248 MHz clock signal, the 32-second major frame signal and a 1 Hz clock signal (minor frame synch signal). From these inputs we generate the timing necessary to contra1 the:

filter wheel rotation
scan mirror drive
data format and storage
power converter frequency
signal collection-and processing

One of the features of the HIRS/2I timing system is that the scan system and filter wheel systems have independent timing circuitry for their individual use when the instrument electronics is off. When electronics is turned on both systems are locked to the spacecraft clock system.

The filter wheel rotation starts independent of the clock system, but when electronics is turned on the filter wheel is controlled such that its rotation rate is synchronous with the 0.1 second timing of the data system and the wheel position is brought into phase with the minor frame synch signal to assure data collection is coincident with the data processing electronics. During each individual radiometric channel collection interval the start and stop of the collection is independent of the clock system being controlled by a timing disk on the filter wheel. This eliminates any disturbance of signal timing by a slight variation in wheel rotation during system operation.

The data from the HIRS/2I system are called from a storage register by the TIP interrogation signal (A, Select). The TIP also provides an 8320 Hz clock to the instrument for clocking out the Digital A data (C, clock pulse). These pulses are defined in the GIIS.

In addition to the clock pulses there is a Calibration Start Pulse occurring every 256 seconds that activates a sequence of scans that provide radiometric calibration of the instrument. When the Calibration Disable command is in effect this calibration pulse will be ignored and the instrument will continue its normal scan sequence.

The major frame pulse is used to establish a reference for the start of scan sequence and to synchronize the retrace telemetry data to the TIP major frame so that electronic calibration and telemetry data go into known data slots.

18.2.2.2.4 Digital A Data Output — The data from the HIRS/2I are provided to the TIP system from a storage register. The TIP clock pulse (C,) and Data Select pulses determine the time at, which data are called out. The TIP formatter calls out groups of 8-bit words in a sequence that multiplexes HIRS/2I data with that of other instruments. Because of the large quantity of HIRS/2I data to be transmitted and the use of 13-bit decoding of radiometric data it was not possible to format the HIRS/2I data into neat 8-bit segments. The HIRS/2I data are therefore provided as a continuous stream with 13-bit word lengths. During any minor frame there are 288 bits of data, each bit identified as to its purpose. The data are described in Table 18.2-8.

The data changes during the scanning process, but the format remains the same during the 56 earth scan elements. During retrace the data format changes to provide measurement of the internal electronic calibration signals and to sample all of the telemetry data.

Table 18.2-8 HIRS/2I Data Output

Element 0 – 55

Bit 1 – 8	Encoder Position
Bit 9 – 13	Electronic Cal Level
Bit 14 – 19	Channel 1 Period Monitor
Bit 20 – 25	Element Number
Bit 26	Filter Sync Designator
Bit 27 – 286	Radiant Signal Output (20 Ch x 13 Bits)
Bit 287	Valid Data Bit
Bit 288	Minor Word Parity Check

Element 56 – 63

Bit 1 – 26	Same as above
Bit 287,288	Same as above

Element 56

Bit 27 – 286	Positive Electronic Cal. (Cal. Level Advances one of 32 Equal Levels on Succeeding Scans)

Element 57

Bit 27 – 286	Negative Electronic Cal.

Element 58

Bit 27 – 91	Internal Warm Target #1, 5 Times
Bit 92 – 156	Internal Warm Target #2, 5 Times
Bit 157 – 221	Internal Warm Target $3, 5 Times
Bit 222 – 286	Internal Warm Target #4, 5 Times

Element 59

Bit 27 – 91	Internal Cold Target #1, 5 Times
Bit 92 – 156	Internal Cold Target #2, 5 Times
Bit 157 – 221	Internal Cold Target #3, 5 Times
Bit 222 – 286	Internal Cold Target #4, 5 Times

Element 60

Bit 27 – 91	Filter Housing Temp #1, 5 Times
Bit92 – 156	Filter Housing Temp $2, 5 Times
Bit 157 – 221	Filter Housing Temp #3, 5 Times
Bit 222 – 286	Filter Housing Temp $4, 5 Times

Table 18.2-8 HIRS/2I Data Output (continued)

Element 61

Bit 27 – 91	Patch Temp Expanded, 5 Times
Bit 92 – 156	First Stage Temp, 5 Times
Bit 157 – 221	Filter Housing Control Power/Temp., 5 Times
Bit 222 – 286	Electronic Cal DAC, 5 Times

Element 62

Bit 27 – 39	Scan Mirror Temp
Bit 40 – 52	Primary Telescope Temp
Bit 53 – 65	Secondary Telescope Temp
Bit 66 – 78	Baseplate Temp
Bit 79 – 91	Electronics Temp
Bit 92 – 104	Patch Temp-Full Range
Bit 105 – 117	Scan Motor Temp
Bit 118 – 130	Filter Motor Temp
Bit 131 – 143	Analog Ground
Bit 144 – 156	Patch Control Power
Bit 157 – 169	Scan Motor Current
Bit 170 – 182	Filter Motor Current
Bit 183 – 195	+15 VDC
Bit 196 – 208	-15 VDC
Bit 209 – 221	+7.5 VDC
Bit 222 – 234	-7.5 VDC
Bit 235 – 247	+10 VDC
Bit 248 – 260	+5 VDC
Bit 261 – 273	Analog Ground
Bit 274 – 286	Analog Ground

Element 63

Bit 27 – 39	Line Count	
Bit 40 – 41	Fill Zeros	
Bit 42 – 44	Inst. S/N	
*Bit 45 – 52	Command Status	
Bit 53 – 57	Fill Zeroes	
*Bit 58 – 65	Command Status	
Bit 66 – 78	Binary Code (1,1,1,1,1,0,0,1,0,0,0,1,1)	+3875 (Base 10)
Bit 79 – 91		+1443
Bit92 – 104		-1522
Bit 105 – 117		-1882

*Command Status Bits

Table 18.2-8 HIRS/2I Data Output (continued)

Element 63 (continued)

Bit 118 – 130		-1631
Bit 131 – 143		-1 141
Bit 144 – 156		+1125
Bit 157 – 169		+3655
Bit 170 – 182		-2886
Bit 183 – 195		-3044
Bit 196 – 208		-3764
Bit 209 – 221		-3262
Bit 222 – 234		-228%
Bit 235 – 247		-225 [illegible]
Bit 248 – 260		+3214
Bit 261 – 273		+1676
Bit 274 – 286		+1992
*Bit 45	Instrument ON/OFF	ON =1
*Bit 46	Scan Motor ON/OFF	ON = 0
*Bit 47	Filter Wheel ON/OFF	ON = 0
*Bit 48	Electronics ON/OFF	ON =1
*Bit 49	Cooler Heat ON/OFF	ON = 0
*Bit 50	Internal Warm Tgt. Pos	TRUE = [illegible]
*Bit 5 1	Internal Cold Tgt. Pos	TRUE = 0
*Bit 52	Space Pos.	TRUE = 0
*Bit 58	Nadir Pos.	TRUE = 0
*Bit 59	Calibration Enable/Disable	ENABLFD = 0
*Bit 60	Cover Release Enable/Disable	ENABLI: [illegible]
*Bit 6 1	Cooler Cover Open	YES = [illegible]
*Bit 62	Cooler Cover Closed	YES
*Bit 63	Filter Housing Heat ON/OFF	O N -
*Bit 64	Patch Temp Control ON/OFF	ON = [illegible]
*Bit 65	Filter Motor Power HIGH	NORMAL =1

*Command Status Bits

Scan Element 0 describes the data at the time of viewing the first scan position. Scan Element 55 designates the last earth scan position. Scan Elements 56-63 occur during retrace during [illegible] earth scanning. The same element number designations continue when the scan is commanded [illegible] a calibration target. Normally the mirror motion between calibration targets takes place during the normal retrace interval. In the case of slew to the space look position the motion occurs during scan elements 0 to 7. Data reduction must take this into account as required.

In order to aid determination of times when data should not be used we have included a Valid Data Bit into the data stream. This bit is a "1" when all conditions are normal and data may be considered good. It will be a "0" when the scan system is in a slew mode or when the filter wheel is not synchronized to the timing system.

The HIRS/2 data output is tabulated in Table 18.2-8. Much of the data format is repetitive for all scan elements. Encoder position is the sensed position of the scan mirror in 1.8" increments. The scan positions are described later, but it may be noted that encoder position "1" occurs at the first earth scan position, hence will be the encoder position noted during element "0".

Electronic calibration level advances from 0 to 3 1, defining the step level measured in each radiometric channel during elements 56 and 57. Since both a positive and negative calibration is made at the end of each scan line the level applies to both. The step level starts at 0 on the first scan after a calibration start pulse and continues repetitively after that, even when calibration is disabled.

Channel 1 Period Monitor measures the variation in time interval of a segment of the filter wheel on each rotation. The reading measures 1.248 MHz clock intervals of that segment, hence defines velocity variations to a granularity of 0.8 microseconds. This is a diagnostic output and is not used in system data processing or evaluation.

Element Number is the number of this data group. It advances from 0 to 63, with element 0 related to the first earth scan position. The element number repeats regardless of scan position or mode.

Filter Sync Designator is a "1" when the filter wheel is in synchronism with the timing system. This is diagnostic data not normally used in data collection or processing.

Radiant Signal Output is the 13 bit level measurement of the signals coming from the various sensors. The first bit is a sign bit ("1" negative, "0" is positive). The data is in binary code from Most Significant Bit to Least Significant Bit.

Minor Word Parity Check is a bit inserted to make the total word odd. This permits automatic checking for data losses in the transmission of the data from the HIRS/2I.

In Elements 58-60 we note that there are four temperature sensors and that each sensor is sampled five times. This provides a more accurate measurement of the critical sensor temperatures.

In Element 6 1 and 62 the data multiplexer connects other voltages and temperature sensors to the analog to digital converter and monitors essentially all of the major test points in the system.

Element 63 consists of command status, instrument serial number, total line number (13 bit natural binary) since the last radiometric calibration, and a fixed pattern of fill bits.

The HIRS/2I instrument serial number is preset for each instrument in element 63, bit 4244. The Protoflight has the designation 001, the flight models will be designated 002 on up.

Command Status is a tabulation of the commands as given at the end of the listing.

18.2.2.2.5 Telemetry Outputs

18.2.2.2.5.1 Digital B Housekeeping Telemetry — The Digital B one-bit status telemetry is available at the instrument interface at all times. The 3.2-second subcom generated by the TIP will sample each Digital B Telemetry Point once every 3.2 seconds. In the HIRS/2I instrument the Digital B outputs are discrete bilevel signals of 0 or 5V nominal relating to a logic 1 or 6. The functions monitored and the state relative to the output level are shown as a part of Table 18.2-9. The Digital B data are available at any time that Instrument Power is ON.

18.2.2.2.5.2 Analog Housekeeping Telemetry – Selected temperature sensors and voltages are provided for analog telemetry. Fourteen positions are brought to the Analog TLM connector. Two additional full time telemetry outputs are also brought to this counter even if the instrument is off.

These points are sampled at either 16 or 32 second intervals as shown in Table 18.2-g.

18.2.2.2.5.3 Full Time Analog Telemetry — A switched + 28V buss is provided to the HIRS/2I for measurement of two temperature sensors even when the instrument is cff. These two sensors are separate from those connected to the instrument power system. A baseplate temperature sensor and a scan motor sensor are considered capable of defining the general system temperature under instrument OFF conditions.

18.2.2.2.6 Mechanical Interface — The HIRS/2I instrument is mounted on the Instrument Mounting Platform (IMP) of the TIROS-N spacecraft. The unit mounts by means of six mounting pads. Mechanical characteristics of the unit are shown in Figure 18.2-5, the HIRS/2 Interface drawing. In this drawing the maximum dimensions of the instrument are shown with the cooler door open and closed and with the thermal blanket in place. The mounts and center of gravity are shown on this drawing.

18.2.2.2.7 Thermal Interfaces — Thermal characteristics of the HIRS/2I are based on a thermal balance providing independence of the instrument from thermal conductina through the mounting surfaces. Temperature control is maintained by the use of a thermal insulating blanket over much of the outer surface of the instrument. The cooler housing openings, scan cavity and sun shields are exposed to space, earth, sun, and spacecraft radiant inputs depending on the view factors. Thermal balance is maintained by radiation from the baseplate through the Temperature Controlled Louvers of the IMP. Since this base radiant area is limited we are providing some added radiant area to the scan housing (20.3 square inches) that had direct emission to space. With this design we can maintain a constant 15°C temperature using only the vane control of the IMP system. Figure 18.2-6 is the Thermal Interface drawing.

18.2.3 OPERATIONAL MODES

The scan system has three basic modes of operations: 1) launch mode, 2) mission mode, and 3) commanded position mode. In addition to these, continuous step mode is introduced automatically if the reference tracks are lost during normal mission mode.

Table 18.2-9 Telemetry

	Digital A	Analog*, Ch. No.	Sample Rate
Scan Mirror Temp	X		
Primary Mirror Temp	X		
Secondary Mirror Temp	X		
Radiator Temp	X	X,6	32
Baseplate Temp	X		
Electronics Temp	X	X,22	32
Patch Temp Full	X	X,231	32
Patch Expanded Temp	X		
Scan Motor Temp	X		
Filter Motor Temp	X	X,246	32
Filter Hsg Temp 1	X		
2	X		
3	X		
4	X		16
Filter Hsg Current	X	X,285	
Warm Tgt Temp 1	X	374	
2	X		
3	X		
4	X		
Cooler Hsg Temp	X		

	Digital A	Analog*, Ch. No.	Sample Rate
Cold Tgt Temp 1	X		
2	X		
3	X		
4	X		
Channel 1 Period	X		
Patch Ctrl Pwr	X	X,255	32
+15 VDC TLM		X,366	16
-15 VDC TLM		X,271	16
+5 VDC TLM		X,301	16
+15 VDC	X		
-15 VDC	X		
+10 VDC	X		
+5 VDC	X		
+7.5 VDC	X		
-7.5 VDC	X		
+10 VDC TLM		X,334	16
-7.5 VDC TLM		X,359	16
+7.5 VDC TLM		X,342	16
Scan Mtr Current	X	X,245	32
F/C Mtr Current	X	X,261	16
Cal Step Voltage	X	262	

Digital B Telemetry	0V (Logic 1) / +5V (Logic 0)
Instrument Pwr	ON/OFF
Electronics Pwr	ON/OFF
Filter Motor Pwr	ON/OFF
Scan Motor Pwr	ON/OFF
Cooler Heater	ON/OFF
Filter Housing Heater	ON/OFF
Cover Release	ENABLE/DISABLE
Window Heater	OFF/ON
Nadir Position	YES/NO
Calibration Sequence	ENABLE/DISABLE
Cover Closed	NO/YES
Cover Open	NO/YES
Filter Motor Pwr	HIGH/NORMAL
Patch Temp Control	ON/OFF

Full Time Telemetry	Sample Rate
Baseplate Temperature	32, Ch. 14
Scan Motor Temperature	32, Ch. 239

*Subcommutated Analog

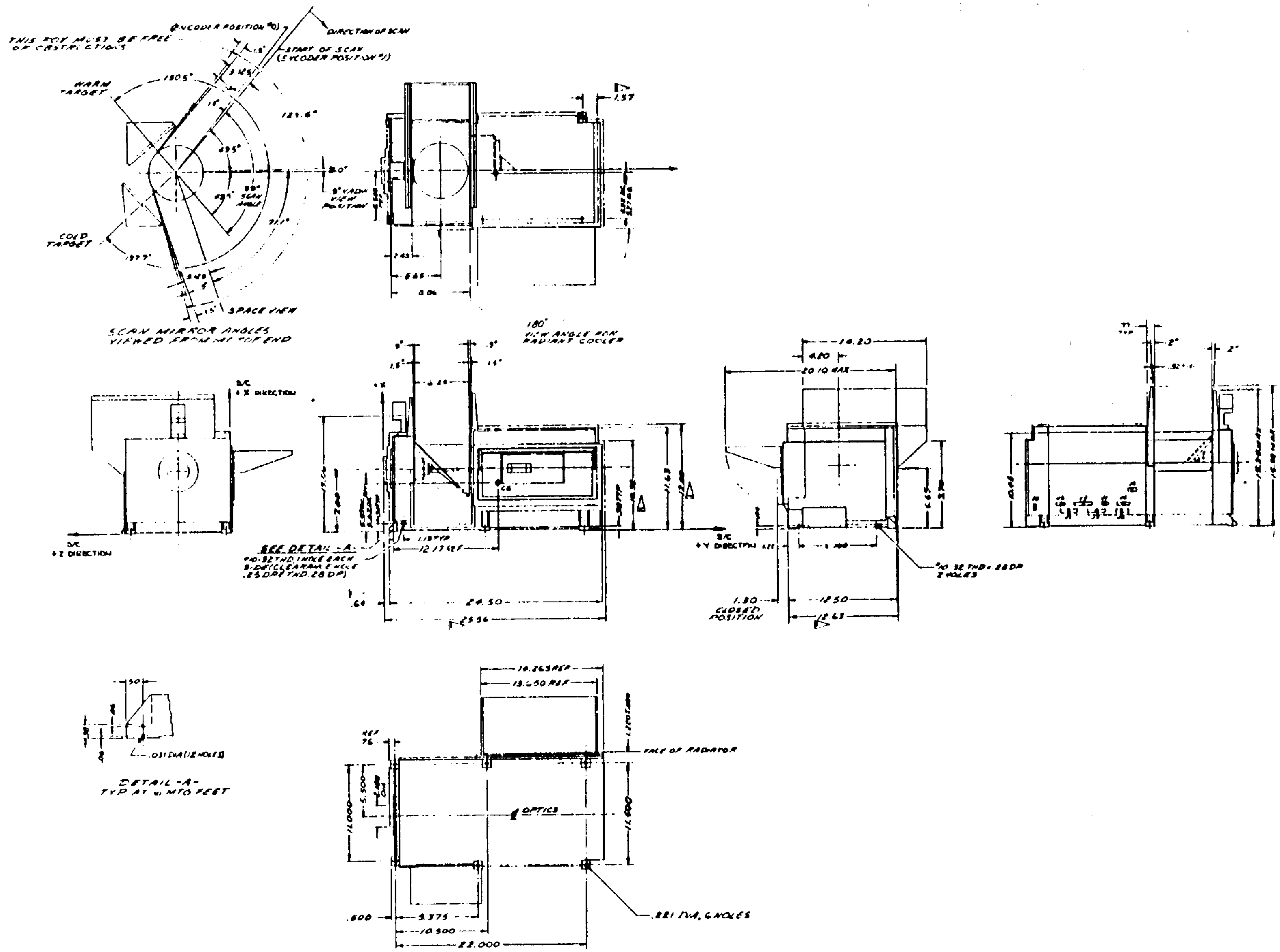


Figure 18.2-5. HIRS/2I interface (outline) drawing.

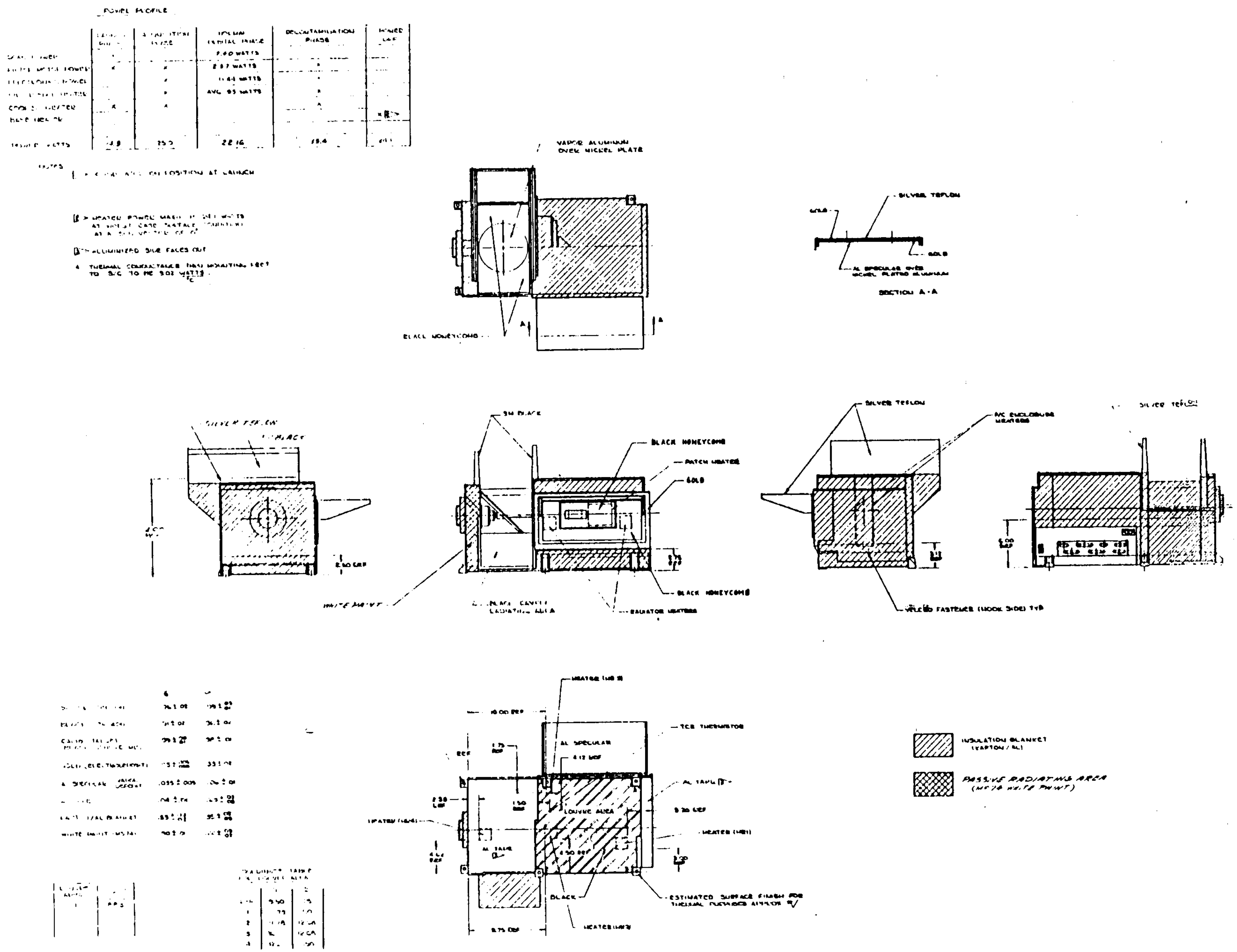


Figure 18.2-6. Thermal interface drawing.

18.2.3.1 Launch Mode

Launch mode is used during the launch of the space vehicle into orbit. The scan mirror rotates continuously at 78 steps per second in the low power mode. This mode is automatically entered when instrument power and scan power are commanded on without electronics power being commanded on.

18.2.3.2 Mission Mode

Mission mode is the normal operating mode of the scan instrument. To enter into this mode, Instrument Power, Scan Power and Electronics Power must all be commanded on. Normally, CAL ENABLE would be commanded on, in which case, the scan would perform a calibration sequence each 256 seconds (40 line intervals). That is, the scan would earth scan/retrace 37 lines, perform a calibrate sequence for 3 line intervals, then repeat. The 3 line calibrate sequence can be omitted by commanding CAL DISABLE. Whenever CAL ENABLE is commanded from a CAL DISABLE condition, the scan will perform a calibrate sequence initiated by the first-major frame pulse following the CAL ENABLE command. Thereafter, a calibrate sequence will be performed whenever a CAL START pulse (256 seconds) is received, as long as CAL ENABLE condition exists. Outgassing of the instrument is done after electronics on is sent (see Activation Sequence 18.2.5).

18.2.3.3 Commanded Position Mode

This mode can only be entered from normal mission mode. CAL ENABLE condition must exist and a Position Commanded (i.e., NADIR, Space, ICT or IW'T). After a position command is entered, the scan will continue its present operation until it reaches start of scan position (REF-O). The scan will then wait at REF-O until the first scan element "0" (SEO) pulse is received from the Scan Element Counter/Decoder. At receipt of SEO pulse, the scan will slew forward to the commanded position. It will remain at the commanded position until a POSITION DISABLE command is received. Immediately upon receipt of a POSITION DISABLE command, the scan will leave the position and slew forward to start of scan position (REF-O).

A position would normally be commanded only in the event of a suspected imminent rotational failure of the Scan System or to extract long-term calibration data at a calibration position.

In the event of imminent failure of the scan rotational system, it may be advisable to achieve the position, then command Scan Power off. In this case, the scan mirror will remain at rest 0.9" (½ step) from the energized position. That is, if Nadir Position is achieved, then, Scan Power Off is commanded, the scan will rest at a position midway between steps 27 and 28 (1.8' from true Nadir).

18.2.3.4 Continuous Step Mode

The Continuous Step Mode cannot be entered into by command. It is entered automatically in the event that both reference track signals (start of scan position) are lost. If the scan is in normal mission mode, (Position Disabled) and two consecutive major frame pulses are received without an REF-O signal being generated, the scan will enter a continuous forward stepping mode at the normal stepping rate of 0.1 seconds per step or 20 seconds per rotation. Complete radiometric data from earth scan, space, ICT and IWT will be available during each rotation. It is possible to modify ground system programs to recover this sounding data, which would include a 56 step earth look and a look at each calibration position on each rotation. The 20 second repetition rate in place of 6.4 seconds would reduce resolution along the satellite track to one-third the original. Calibration data would need to be accumulated for averaging.

18.2.4 FUNCTIONAL DESCRIPTION

Figure 18.2-7 is a basic block diagram of the Scan System. The heart of the scan system is a stepper motor with 200 steps per rotation. Assembled to the shaft of the stepper motor are (1) a scan mirror mounted with the mirror surface plane at 45° with respect to the axis of the motor shaft, (2) a DC torque motor, (3) a DC tachometer, (4) a shaft position encoder and (5) a two contact slip ring assembly.

The drive control signals for the stepper motor are generated by a step generator which has input control features for retrotorque control, step/slew control and rotational direction control (up/down). Output from a scan regulator with power level control is applied to the motor driver to provide stepping torque levels as required.

Scan Control logics utilize timing signals and position commands in conjunction with position information derived from a position encoder to monitor and control performance of the system.

A tachometer is used to derive rate information which is used to control a DC torque motor to aid stopping of the scan rotation as the scan settles into a track position or into a step position.

Connections to a thermal sensor on the scan mirror are provided via two leads from the mirror through the hollow motor shaft to a slip ring assembly at the opposite end of the shaft.

The following discussion is a detailed functional description of the scan system as it performs under the several possible conditions. The conditions include launch mode, mission mode (with variations of commands) and failure modes. This description will not refer to any command functions other than those directly relating to scan system performance (e.g., Filter Motor Power would normally be commanded on during the turn-on sequence of commands. However, it will not be included in the turn-on sequence of commands in this description). (Figure 18.3-8 is a detailed block diagram of the scan system to aid in following this description). The functional blocks in this diagram do not represent division of functions per subassembly, pw board, etc. as they are incorporated in the scan system.

18.2.4.1 Launch Mode

To enter launch mode, Instrument Power and Scan Power must be commanded on without Electronics Power being commanded on. In this condition, absence of ± 1 OVDC-2 is detected and the following conditions are forced:

(a) The REF LOST detector is held in reset condition.

(b) GO-TO logic is inhibited from recognizing a Position Command.

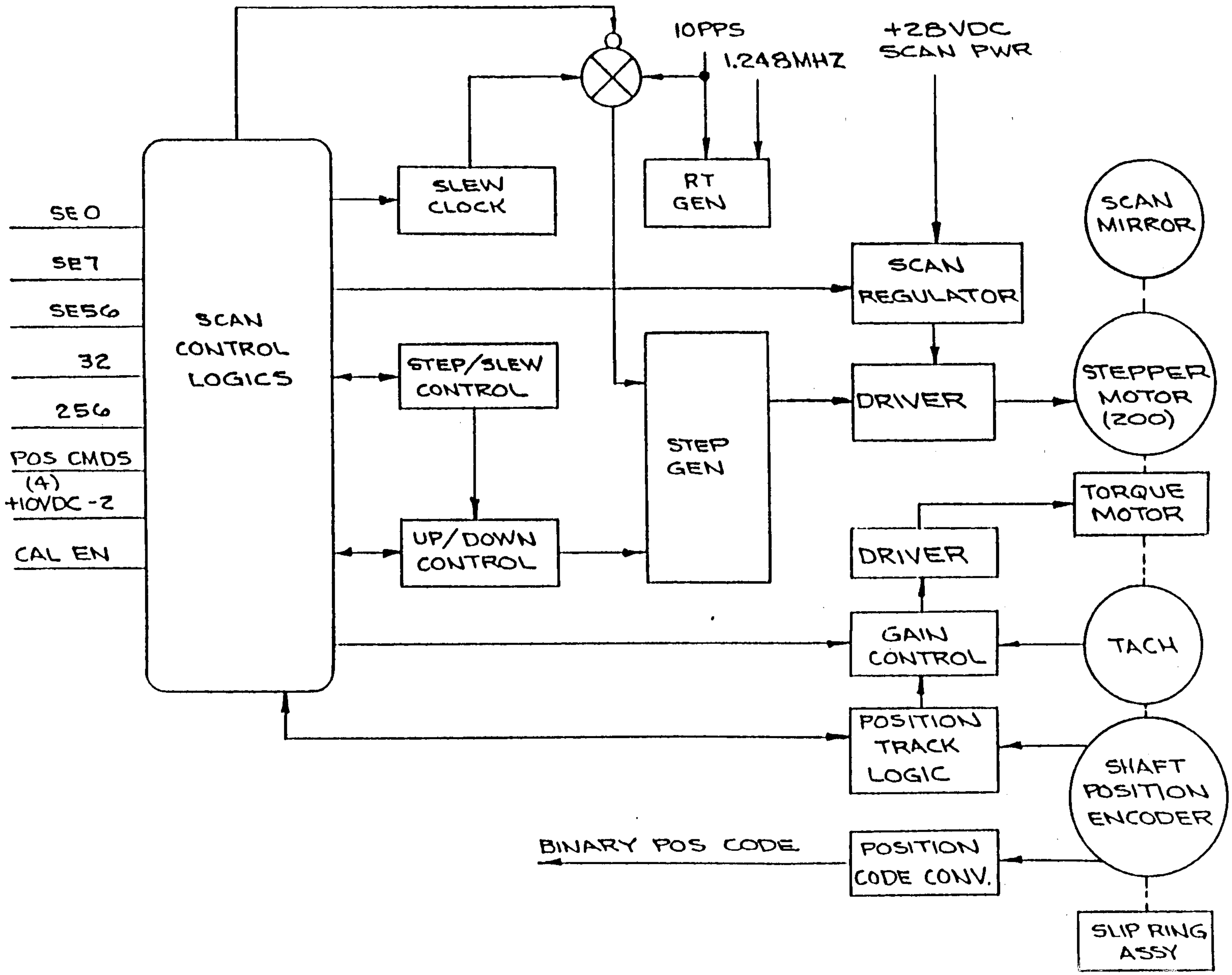


Figure 18.2-7. Scan system basic block diagram.

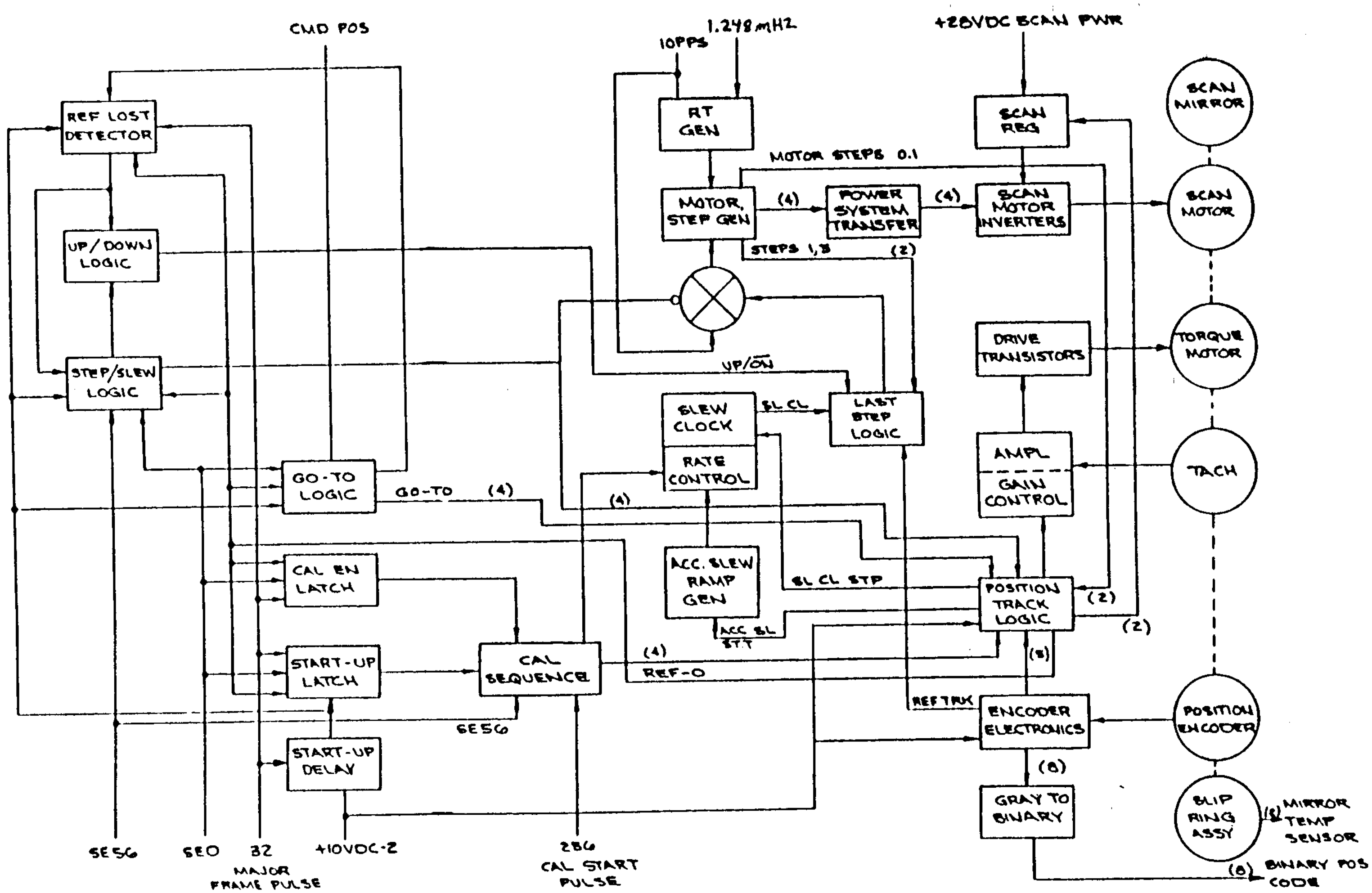


Figure 18.2-8. Scan system detailed block diagram.

(c) STEP/SLEW logic is forced into slew condition, which in turn forces UP/DOWN logic into UP condition.

(d) Power control logic (within position track logic functional block) controls the scan regulator to launch power level (low power).

(e) Encoder electronics are inhibited from generating position track signals,

Thus, during launch mode the scan slews up (forward) at low power level and cannot be commanded to a position or receive a reference track signal (start of scan position).

18.2.4.2 Mission Mode

To enter Mission Mode from launch mode only requires that Electronics Power be commanded on. It should be noted that when Instrument Power is commanded off, CAL ENABLE and POSITION DISABLE are automatically accomplished.

When Electronics Power is commanded on, encoder electronics and position track logic are immediately enabled. This causes scan power to immediately go to high power mode, slew rate remaining at 78 steps per second until the scan reaches REF-O. This track is now recognized; the slew clock is commanded to stop and the scan regulator is switched to low power, When the scan enters th.e REF track, which is 5.4° of arc, the amplifier controlling the torque motor is switched to high gain condition to assist in stopping the scan motion. This damping action endures for about 80 milliseconds. The track, in conjunction with motor step zero (of zero through 3) causes the stepper motor to settle with the scan centered in the REF track. Also, when Electronics Power is commanded on, a start-up delay latch is enabled, which is set on the trailing edge of the [illegible] following major frame pulse (32). This in turn enables the REF LOST detector and CAL STT-UP latch. The STEP/SLEW logic is still forced into SLEW condition (now by virtue of the CAL STT UP latch being set), thus, the scan remains at start of scan position.

The leading edge of the next major frame pulse clocks the STT-UP latch to a second [illegible]. This initiates a calibrate sequence, which is controlled by a shift register in the CAL SEQUENCE GENERATOR. Now a signal indicating that a calibrate cycle is in process continue? to force the STEP/SLEW logic to SLEW condition.

When the calibrate sequence is initiated, the REF-O latch is cleared, the slew clock [illegible], and the shift register prepares the position track logic circuits to recognize SPACE TRACK, [illegible] STEP 0. Removal of the SL CL STP (slew clock stop) signal causes an ACC SL ST (accelerated slew start) pulse to be generated. This initiates generation of an accelerated slew/ramp by a generator which contains an oscillator, up/down counter and DAC, along with associated control logic. Duration of the up/down ramp is 0.5 seconds. It is applied to the slew clock rate control and causes the slew rate to increase for about 0.25 seconds, then decrease in the next 0.25 [illegible] (again to 78 steps per second). Amplitude of the ramp is determined by switching [illegible] the DAC output, the switching being controlled by the CAL SEQUENCE shift register. Slew to SPACE position has the most severe ramp, resulting in a peak slew rate of nearly 200 steps per second. Slew from position to position during a calibrate sequence is nominally accomplished in 0.5 to 0.6 seconds then allowing 0.2 to 03 seconds additional (0.8 seconds total) for settling into the position.

Subsequently, SE56 pulse from the Scan Element Counter/Decoder advances the shift register until it has cleared itself. At this time, the scan has advanced to REF-O and is awaiting the next SEO Pulse from the Scan Element Counter Decoder to initiate its next action.

If no other command has been given (such as a Position Command), at receipt of SEO signal, the step latch will be set (in the step/slew logic) and the stepper motor willbegin to step forward (up) at 10 steps per second as determined by 10 pps from the Scan Element Counter/Decoder. A special feature called' retrotorque damping is used to control the characteristic with which the scan settles into each step position. At the time that the motor winding control is changed to a braking function (retrotorque), the DC torque motor is energized to aid in step settling.

Stepping continues at 10 steps per second until SE56 is received. At this time, the step latch is reset to slew condition, the UP/DOWN latch is reset to down, the scan power level is switched to high, the slew clock is enabled and an accelerated slew ramp is generated. Thus, at receipt of SE56, the scan ramp slew backward (down or "retrace") at high torque level until it reaches the reference track, motor step 0, at which time the slew clock is commanded to stop, the scan halts and scan power level goes to low. (It should be noted here that the scan will always stop at REF-0 when Electronics Power is on, and wait for the next SEO pulse before proceeding with any further action.) Unless altered by receipt of another command, the scan will continue this step/retrace until a cal start (256) pulse is received, at which time an automatic calibrate sequence is again performed. As long as CAL ENABLE command is in effect, and no other command is received to alter scan operation, the scan will continue repeating scan/retrace for 37 lines, calibrate sequence for 3 line intervals.

If a position is commanded with CAL ENABLE in effect, the scan continues its present operation until it reaches REF-O. There, it awaits SEO signal at which time step/slew logics are forced to slew condition, which in turn forces up/down logic into UP condition. An accelerated slew ramp is generated, however, severity of rate control is very slight. When a Position Command has been acknowledged, all other scan operations are ignored until a POSITION DISABLE command is received. A position command cannot be received unless CAL ENABLE is in effect. However, once the Position command has been received, the Position will be maintained even though CAL DISABLE command has been received.

Upon receipt of POSITION DISABLE command, slew clock is enabled, accelerated slew ramp is generated, scan power level goes high. Thus, the scan ramp slews forward immediately in search of REF-O position.

When CAL DISABLE is in effect, CAL START (256) pulse is ignored and position commands are ignored. Thus, the scan enters a continuous step/retrace mode.

18.2.4.3 Continuous Step Mode

If, during mission mode, the reference tracks fail, the scan will continue its present operation until it seeks the reference track, motor step 0 (REF-O). If this is during retrace, it will continue slewing until SEO signal sets the UP/DOWN logic to UP condition. Then, it will slew forward in search of REF-O. This will continue until the 2nd major frame pulse, at receipt of which the reference lost latch is set, forcing the step/slew logic into step condition, and UP/DOWN logic into UP condition, disabling SE56 from reversing the UP/DOWN logic. Thus, the scan will continuously step forward in low power mode. Calibrate logic is disabled. Position commands can be received if CAL ENABLE is in effect. However, the position will be achieved by position track logic disabling the step generator when the position has been reached. When the position disable command is given, the step generator is enabled and the scan continues stepping forward at 10 steps per second.

If at any time a reference track signal is generated, the REF LOST latch is reset and normal operation is attempted.

18.2.5 ACTIVATION SEQUENCE

18.2.5.1 HIRS/2I 30°C Radiant Cooler

The activation sequence for the HIRS/2I instrument (FM-11 through -71) with its 30°C radiant cooler decontamination heater is as follows:

(a) Commands Prior to Launch – Instrument On (H2PON), Scan Motor On (H2SMN), Filter Motor Normal Power (H2FMN), and Filter Wheel Motor On (H2FWN). Note: The stored command "on/off' for the outgassing/cooler heater may remain unchanged as a precautionary measure against accidental HIRS/2 cooler door deployment.

(b) Gilmore 1 Commands – Electronics On (H2ELN) and Cooler Heater On (H2CHN).

(c) Wallops 2 16 Commands – Cooler Door Release Enable (H2CRE), command spacecraft 28 volt bus current, analog telemetry channel 296, into 1 second dwell modes prior to (H2CCD); Cooler Door Deploy (H2CCD); Cooler Door Release Disable (H2CRD), command spacecraft 28 volt bus current 1 second dwell mode off; Cooler Heater Off (H2CHF); and Patch Temperature Controller On (H2PCN).

18.2.6 CONSTRAINTS

18.2.6.1 General

The various modes of operation have specific requirements (constraints) that must be met, either prior to initiation of a mode or after it has been established. Constraints imposed for the various operating modes are listed in the following paragraphs.

18.2.6.2 Prelaunch Mode

(a) The cooler door must be verified latched.

(b) Cooler and scan cavity dust covers must remain in place for testing.

(c) Baseplate temperature limits, during all modes, is 10 to 30°C.

(d) The decontamination heater system for the radiant cooler is a thermostatically controlled system designed to limit radiant cooler temperature to a maximium of 30°C.

Special precautions must therefore be taken when operating the cooler heater in testing these instruments to avoid detector temperatures in excess of 30°C because of possible detector degradation or failure. HIRS/2I FM-1 I through -31 have been built to prevent the cooler heater from heating the radiant cooler above 30°C.

18.2.6.3 Launch Mode

(a) Verify that dust ***covers*** are removed prior to launch.

(b) The cooler door can be opened only once, and not reclosed. Therefore, it should not be opened until after the initial outgas period.

(c) For protection of bearing surfaces, etc., the HIRS/2I should be launched with the scan mirror ON.

(d) The chopper-filter motor should be ON at launch.

(e) The chopper-filter motor should be in NORMAL (low) mode at launch.

(f) In order to execute a go-to command the instrument must be in the calibration ENABLE mode.

(g) See activation sequence 18.2.5.

18.2.6.4 Orbit Mode Constraints

The cooler door opening mechanism has a time-out device which automatically disables the solenoid after the door has opened. For safety, however, the cover release DISABLE command should be transmitted after positive indication has been received that the door is open.

18.3 MICROWAVE SOUNDER UNIT (MSU)

18.3.1 FUNCTIONAL DESCRIPTION

18.3.1.1 Objectives

The TIROS-N Microwave Sounding Unit (MSU) is designed to accomplish two basic objectives:

(a) To map the temperature profile of the atmosphere from 0- to 20-km altitude, even in the presence of clouds.

(b) To acquire a unique global data set for operational use. The data will be a part of the continuous operational meteorological data which are a primary goal of the TIROS Operational Satellite System.

18.3.1.2 Basic Operational Theory

The instrument objectives are accomplished by scanning the atmosphere transverse to the orbit plane and separating the received microwave radiation into their vertical and horizontal polarization components. This received signal is a measure of the effective noise temperature at the sampled atmospheric height. Through a series of internal calibrations and temperature comparisons with ambient reference loads an atmospheric temperature profile is derived.

18.3.2 SYSTEM DESCRIPTION

18.3.2.1 General

The MSU instrument is a four-channel scanning microwave radiometer system comprised of two scanning reflector antenna systems, orthomode transducers, four Dicke superheterodyne receivers, a data programmer, and power supplies (see Figure 18.3-1). The antennas perform a 94.8-deg scan transverse to the orbit plane, 47.4 deg on each side of nadir. A space and an internal blackbody view for calibration purposes will also be used. The beamwidths of the antennas are approximately 7.5 deg, resulting in a resolution on the ground varying from a circle with a diameter of 109 km, to an ellipse with a major axis of 323 km and minor axis of 179 km, depending on the scan angle (see Figure 18.3-2), and a swath width of about 2320 km. The scan is stepped; i. e., the beams are always scanned in the same direction while taking data with a rapid step to the next data-taking position. The rate of scan is such that almost continuous coverage of the ground is provided. A step-scan system is used to avoid smearing of the data in the scan direction. One complete scan is accomplished every 25.6 sec.

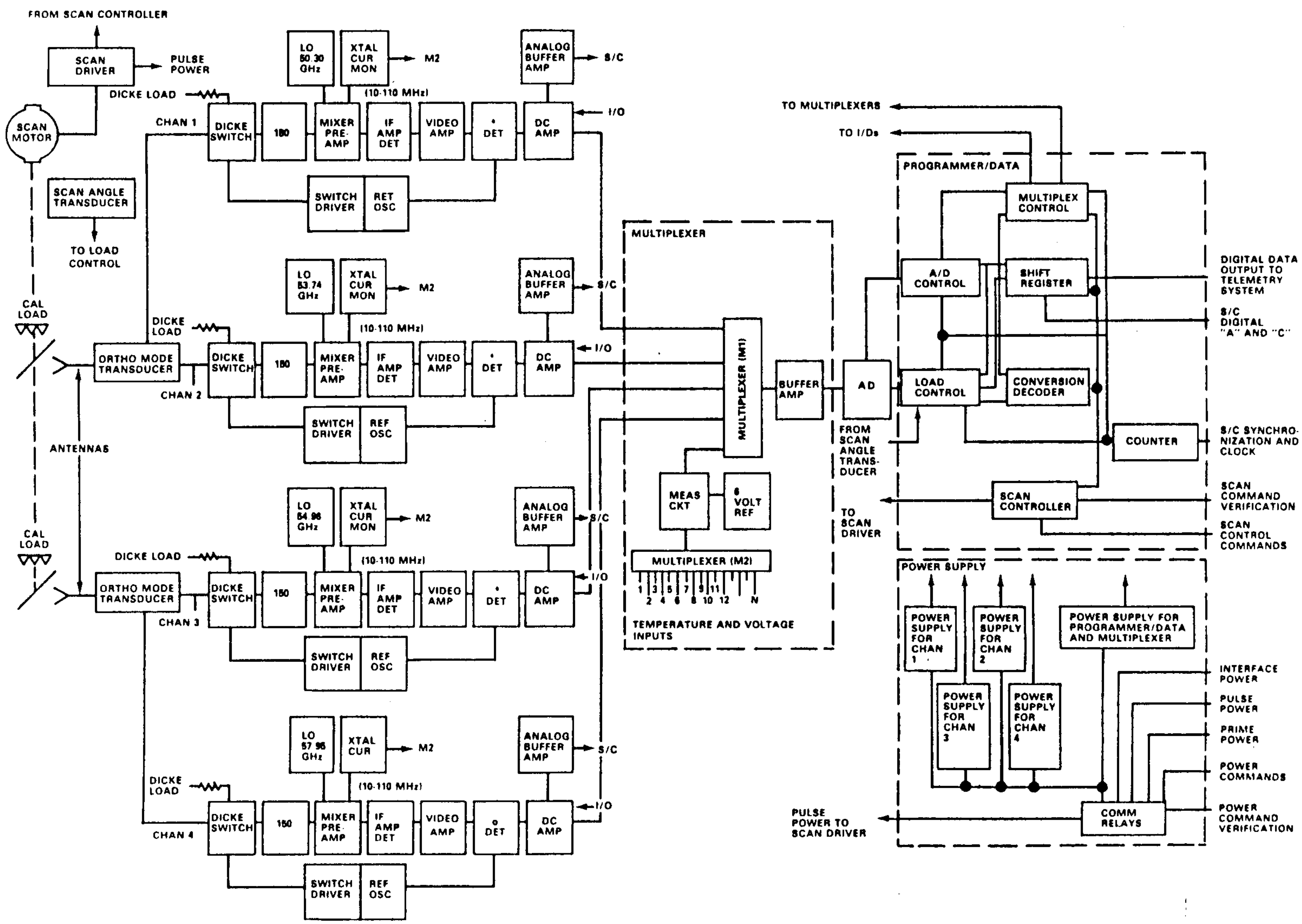


Figure 18.3-1. TIROS-N Microwave Sounder Unit Functional Block Diagram

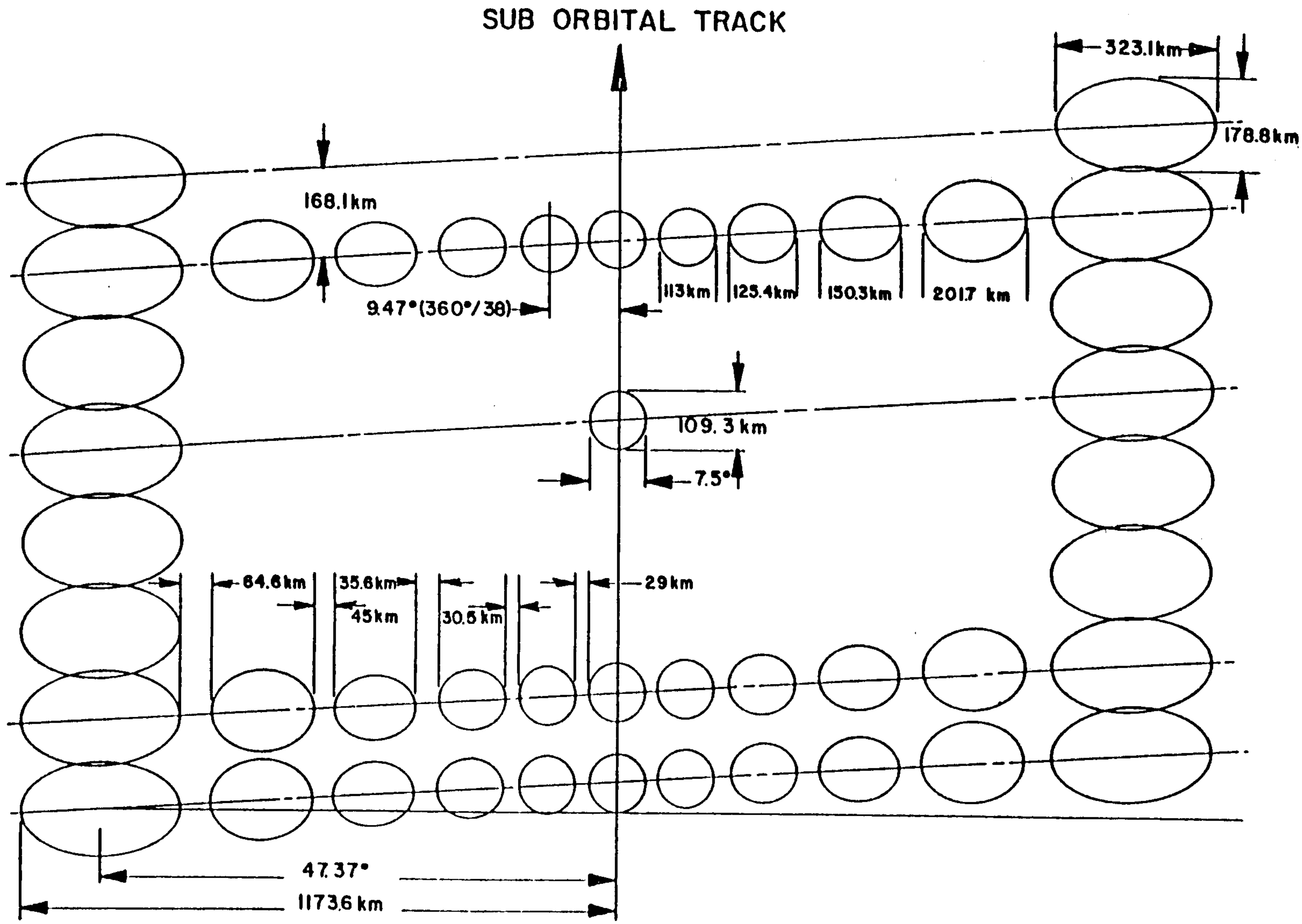


Figure 18.3-2 MSU Scan Pattern

Microwave energy received by each antenna is separated into the vertical and horizontal polarization components by an orthomode transducer. Each of these four signals is then fed to one of the radiometer channels. Each incoming noise temperature is modulated at a 1-kHz rate by a Dicke switch such that a repetitive comparison is made between an ambient temperature reference load and the incoming signal. A two-point calibration is accomplished by a cold-space view and a blackbody view, once each scan period. The modulated signal is passed through an isolator and then mixed in a low noise balanced mixer with a local Oscillator (LO) signal to produce an IF frequency with a pass band of 10 to 110 MHz. The signal is further amplified in IF and video amplifiers and then demodulated by the phase detector. The final signal amplification takes place in the integrator and dc amplifier where it is integrated 1.82 sec. Each radiometer output is -5 to +5 Vdc for 0- to 350-K equivalent noise temperature input at the front end. Each radiometer channel gain is 28.6 mV/°K. A summary of MSU characteristics is given in Table 18.3-l. Figure 18.3-l is a functional block diagram of the MSU; Figure 18.3-2 shows the instrument scan pattern projected upon the Earth; and Figure 18.3-3 is a drawing of the instrument.

TABLE 18.3-l. SUMMARY OF MSU CHARACTERISTICS

Characteristics	Channel			
	R_1	R_2	R_3	R_4
Frequency (GHz)	50.30	53.74	54.96	57.95
RF bandwidth (MHz)	220	220	220	220
Integration time (sec)	1.8	1.8	1.8	1.8
ΔT_{rms} (K) for 1.8 sec integration time	0.3	0.3	0.3	0.3
Dynamic range (K) (min)	O-350	O-350	O-350	O-350
Instrument absolute accuracy (K rms) (long term)	<2.0	<2.0	<2.0	<2.0
IF Frequency Range (MHz)	10-110	10-110	10-110	10-110
Antenna beamwidth (deg)	-7.5	-7.5	-7.5	-7.5
Antenna beam efficiency (%)	>90	>90	>90	>90

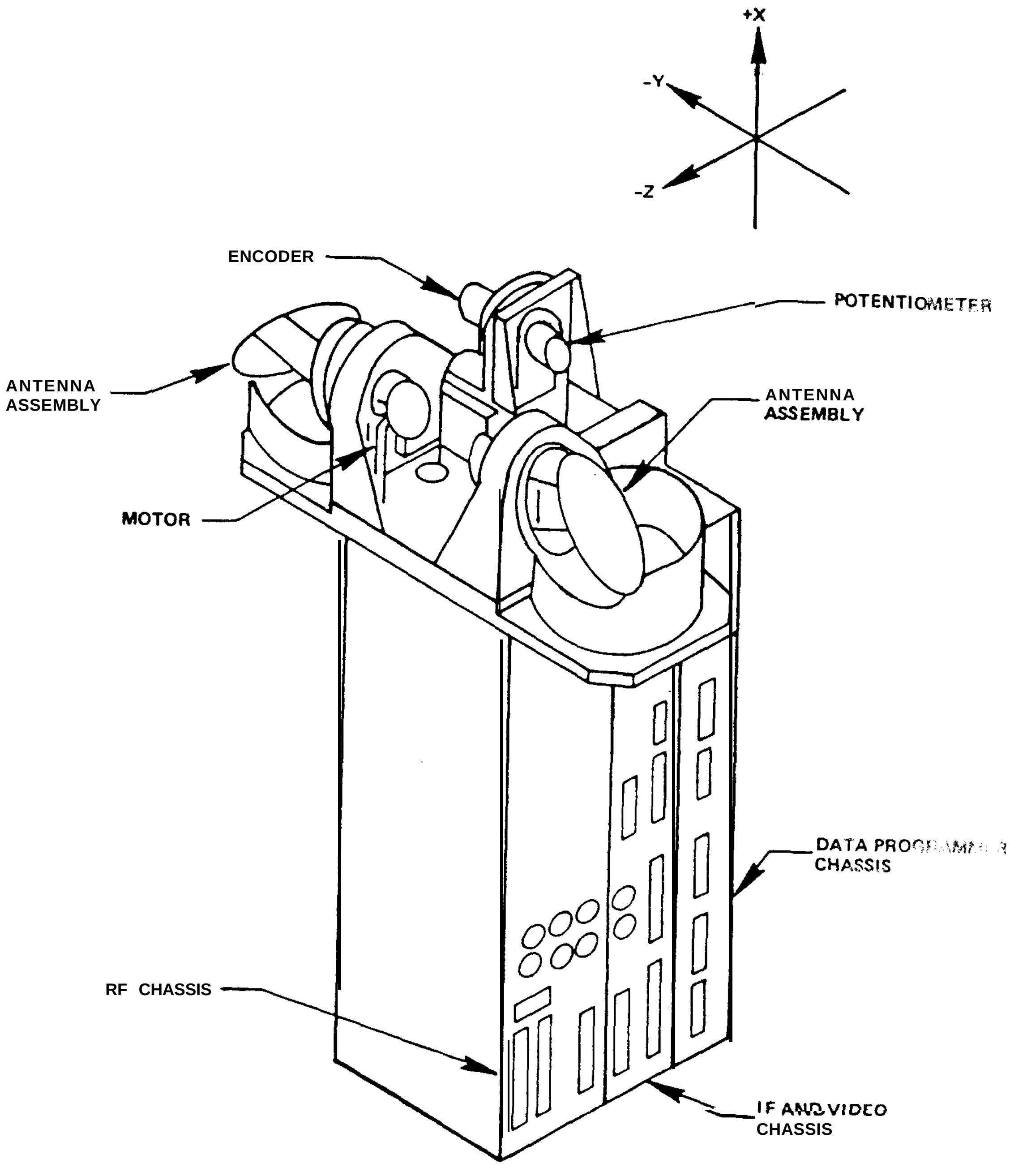


Figure 18.3-3. MSU Scan and Electronics Modules

The MSU is comprised of the following three modules and their component subassemblies:

(a) Scan Mechanism-The scan mechanism is made up of the following:

(1) Two antennas

(2) Antenna drive, positioning and measuring subassembly

(3) Structural support subassembly

(b) Instrument Electronics—The instrument electronics consists of the following:

(1) RF chassis

(2) IF/video chassis

(3) Data chassis

(c) Power Supply-The power supply is made up of six (four identical) power submodules.

These -modules are shown as integral assemblies in Figures 18.3-3 and 18.34

18.3.2.2 MSU Scan Mechanism

The MSU scan mechanism, as the name implies, accomplishes the scan pattern of the instrument. This mechanism includes the antennas, antenna drive, positioning and measuring subassemblies, and the associated structural support assemblies.

18.3.2.2.1 Antenna-The antenna submodule consists of two rotating reflectors with fixed corrugated feed horns. The reflectors are supported by high precision, low-torque ball bearings. The bearing inner races are stationary and are attached to the antenna feed horn structure. The reflectors are attached to the outer races that are rotated by highly accurate pulley drives. The pulley drive is radially supported from the bearing by titanium flanges to reduce thermal expansion/contraction effects. To meet the sensitivity requirement of 0.30 krms, two antenna assemblies, which have significantly lower losses than a single antenna assembly, are used. Associated with each antenna is an orthomode transducer. The orthomode transducer separates the vertical and horizontal polarization components of the broadband incoming signal; each is tuned to one of the MSU operating frequencies and appears at the output ports of the transducer. Table 18.3-2 lists the antenna parameters.

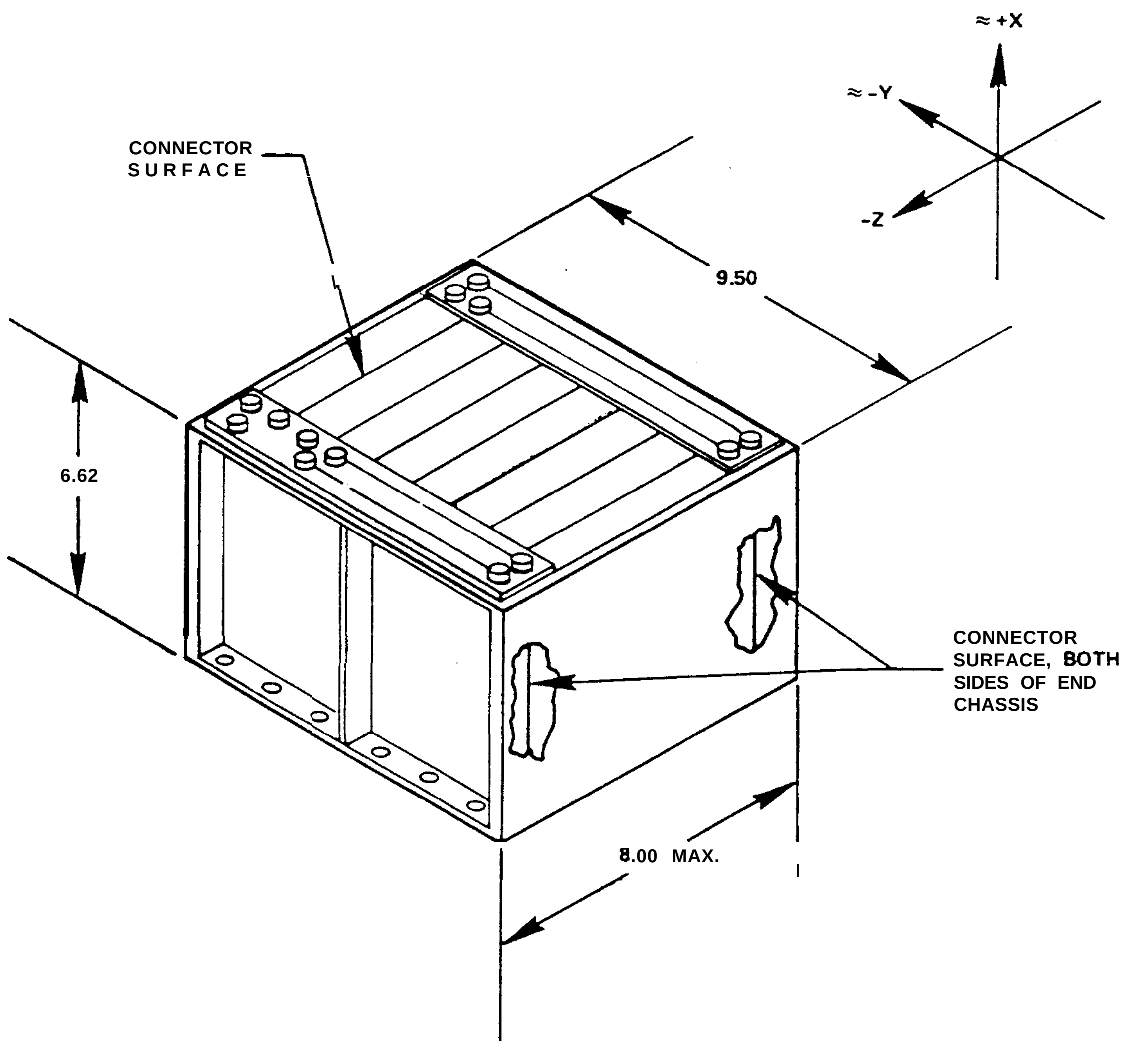


Figure 18.3-4. MSU Power Supply

TABLE 18.3-2. ANTENNA PARAMETERS

Parameters	Values	
Operating Frequencies	Antenna 1	50.30 and 53.74 GHz
	Antenna 2	54.96 and 57.95 GHz
Bandwidth at each frequency	±200 MHz	
Half power beamwidth	7.5 nominal	
Beam efficiency	90% minimum	
Polarization	Linear, polarization at each frequency determined by ortho-mode transducer	
VSWR	Less than 1.20;1	
Side lobe amplitude	-23 dB maximum	

18.3.2.2.2 Antenna Drive Positioning, and Measuring Subassembly-The antennas are driven by a 90-deg stepper motor and-a set of high precision miniature gear belts. The motor to antenna pulleys have a reduction ratio of 9.5 to 1. The belts are made from precision-molded polyurethane elastomer with dacron filaments and are slip-proof for constant accuracy. Synchronized engagement is maintained with matching miniature pulleys that are flanged to prevent belt walk-off. Under the control of digital electronic circuitry, the motor takes single steps, *or runs* continuously for a predetermined number of steps, to position the antenna at each angle required for taking measurements. After the antenna reaches each position, power remains on the motor for 40 msec to provide braking and mechanical damping.

The antenna positions are monitored by a potentiometer and an encoder. The potentiometer is a single turn with continuous rotation and has infinite resolution over 350 deg of travel. The encoder is a disc type, generating angular position with a resolution of 256 counts per revolution. The potentiometer and encoder are connected to the same shaft drive as the antennas using identical belts and gear ratios. One antenna has a stationary E-core with a pick-off core attached to the antenna/bearing flange to provide an electrical signal when the antenna reaches the zero position.

18.3.2.2.3 Structural Support Subassembly-The structural support subassembly which includes a base plate and several support brackets is made of aluminum. Each antenna has a microwave blackbody calibration load where the antenna dwells for 1.9 sec. These calibration loads consist of parallel rows of knife edges made by casting an iron-filled epoxy onto an accurately machined aluminum backing plate. The aluminum's high conductivity minimizes thermal gradients in the iron-filled epoxy; the epoxy composition and shape provide, essentially, a blackbody target for the antennas. These targets, essentially isothermal and at a measured temperature, provide one of two calibration points that each antenna sees every revolution. The second calibration is provided, at a lower temperature, by a view of space. The metal surfaces of the structural components are either hand polished or carefully cleaned to increase the thermal emissivity. The entire scan mechanism, except for the antenna viewing, is enclosed by a fiberglass shield to minimize heat losses. The shield has shiny aluminum foil attached to the inside surface and is painted white on the outside surface.

18.3.2.3 MSU Instrument Electronics

The instrument electronics consists of three chassis, namely the RF, IF, video, and data chassis. These three chassis are mechanically connected by support brackets, radiator plates, and the antenna subsystem base plate; together they comprise the four radiometer channels, the multiplexer, and the data programmer shown in Figure 18.3-1. Each channel of the radiometer is self-contained and can be used independently of any other channel(s). The design is a conventional Dicke radiometer with a switching rate of approximately 1000 Hz. Each channel is identical except for the operating frequency and is comprised of solid state components. The incoming signal is connected to the Dicke switch. The Dicke switch alternates between a microwave load at instrument temperature and the incoming signal. This modulated switch output is fed through an isolator to a low noise balanced mixer preamplifier. The local oscillator is a Gunn diode unit and provides approximately 10 mW of power at the particular channel frequency. The RF bandwidth of the mixer is ±300 MHz from its nominal operating frequency. The IF bandpass extends from 10 to 110 MHz; the predetection bandwidth is, therefore, 100 MHz. This signal is further amplified in the post IF amplifier and square law detected. The detected signal is amplified by the video amplifier and then synchronously detected. The output of the synchronous detector is the difference between the antenna signal and the reference load (T constant). The resultant dc signal is proportional, therefore, to the antenna temperature, and it is further amplified by a dc amplifier. This signal is available as the analog output. The detected signal is also integrated for 1.8 sec and then digitized by the 12-bit Analog to Digital (A/D) converter.

18.3.2.4 MSU Power Supply

The power supply is mounted remotely from the rest of the instrument. It consists of six chassis, four of which are identical. All exterior exposed surfaces are painted black.

18.3.2.5 Temperature Monitoring

There are four analog telemetry channels monitoring temperature: one each on the two Dicke switches and one each on the two in-flight black bodies. The temperature sensors are thermistors.

18.3.2.6 Calibration

MSU radiance data for each of the four charnels are essentially temperature difference information, between the incoming noise temperatue as seen by the scanning antennas and an ambient temperature reference load as generated within the instrument electronics. The actual temperature difference values (thus the temperatures themselves) of the various Earth samples are determined from the instrument output signals by referencing to the values for two known temperature sources, the blackbody target (hot) mounted upon the structural subassembly, and space (cold). Additions3 information needed for temperature determination from radiance data is found in the telemetry temperature monitors of the instrument, the reference load and the calibration target temperatures, and the calibration curves determined during prelaunch testing and is found by comparison with similar data from other instruments and from operational meterological and oceanographic stations.

18.3.2.7 System Timing

The data programmer interfaces to the spacecraft 1.248-MHz clock and the 128-sec clock A_1 and C_1 pulses, and utilizes these signals for timing and synchronization of the experiment operation and the data output. Each scan period is synchronized at 25.6 sec and comprises 11 Earth-viewing periods, a space view calibration period, a microwave blackbody view calibration period, and the various stepping and slewing periods required between the viewing periods for the mirror to be stepped to its next position. There are five of these full 25.6-sec scan periods during each spacecraft 128-sec clock period. The scan cycles are illustrated in Figures 18.3-5 and 18.3-6. Under normal operating conditions, the antenna is inherently synchronized to the digital circuitry driving it, and the digital circuitry is synchronized to the spacecraft by the 128-sec pulse.

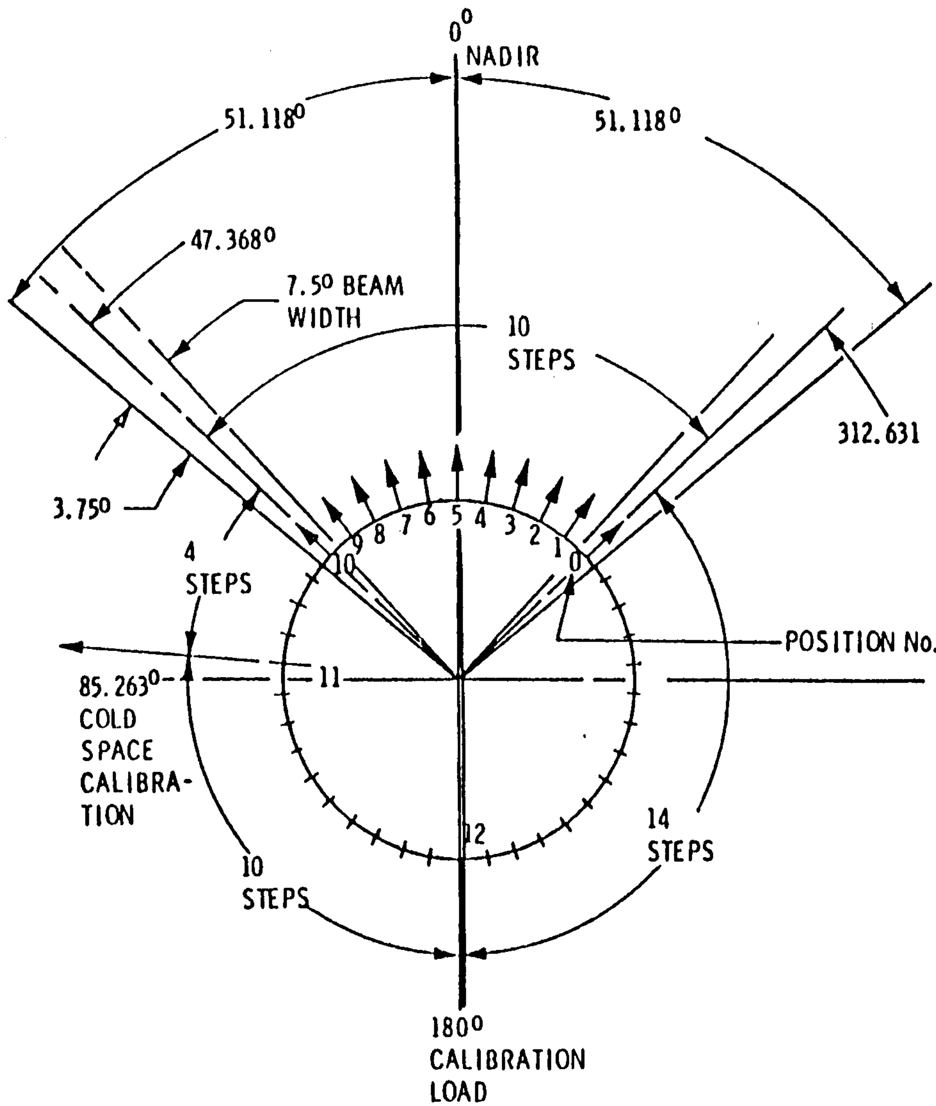


Figure 18.3-5. Earth Scan Views

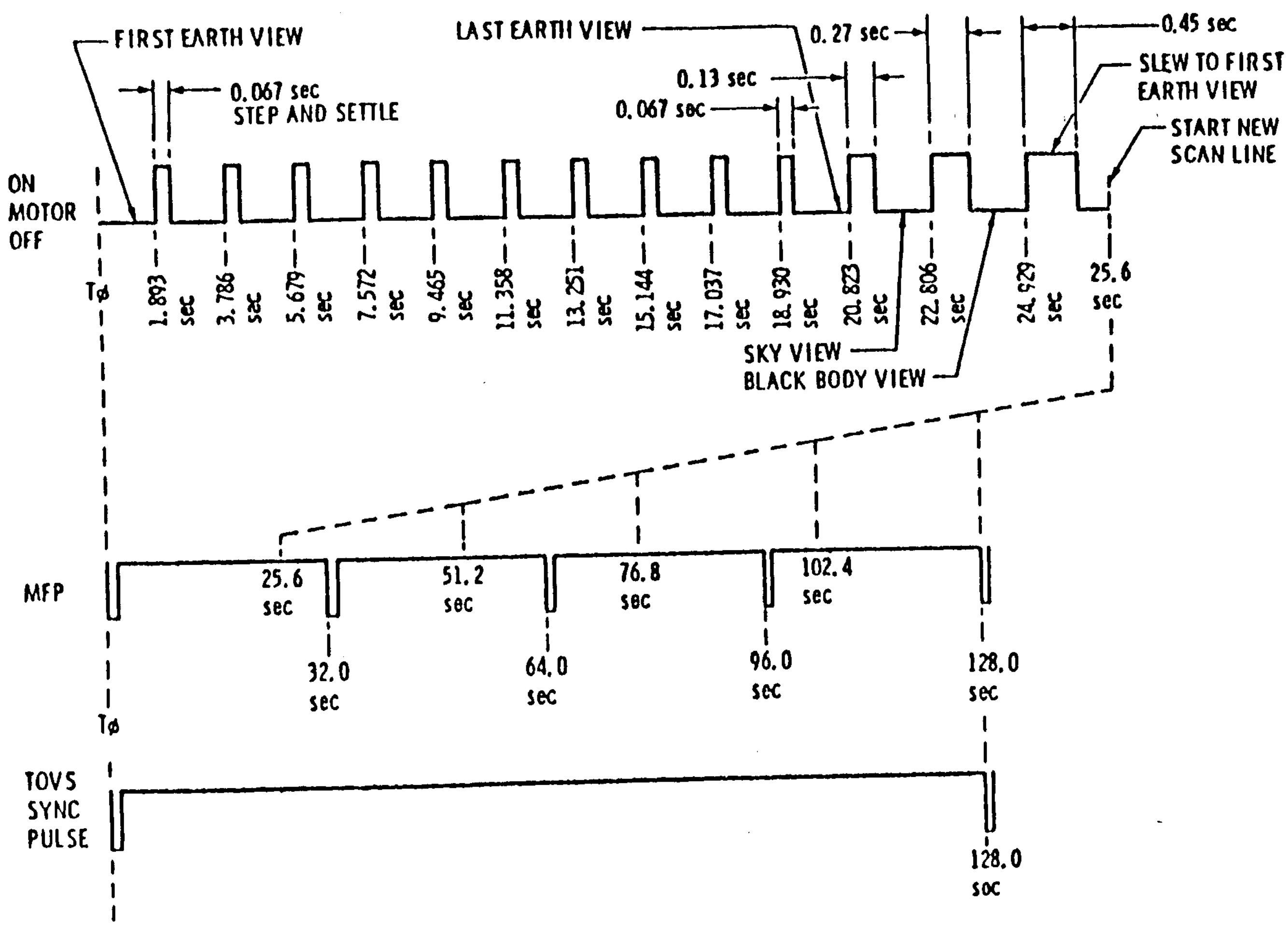


Figure 18.3-6. MSU Scan Timing Diagram

The following list is the typical sequence of events which lead to the establishment of synchronism between the antenna and the spacecraft:

(a) The digital circuitry comes on in some arbitrary state.

(b) The antenna becomes synchronized to the digital circuitry within 25.6 sec.

(c) The digital circuitry becomes synchronized to the spacecraft via the receipt of the 128-sec pulse. As a result, synchronization between the antenna and the digital circuitry is lost.

(d) The antenna again becomes synchronized to the digital circuitry within 25.6 sec.

The actual timing breakdown is as follows:

(a) Earth scan position zero timing:

(1) Antenna step and settling time, 0.067 sec

(2) Antenna dwell time, 1.826 sec

(3) Integration period, 1.82 sec

(4) Total time per step, 1.893 sec

(b) Earth scan positions 1 through 10 have timing periods identical to that of step 0, with step 10 ending 20.823 sec after the start of scan.

(c) Calibration scan timing:

(1) End of step 10 dwell and start of 4 steps to space, 20,823 sec

(2) Start of space dwell (step 11), 22.806 sec

(3) Space integration period, 1.82 sec

(4) Start of 10 steps to absorber, 22.806 sec

(5) Start of ambient absorber dwell (step 12), 23.068 sec

(6) Ambient absorber integration period, 1.82 sec

(7) Start of 14-step slew to first Earth view, 24.929 sec

(8) Antenna retrace and wait period, 0.671 (includes 0.45 sec for moving to step 0 and approximately 0.22 sec waiting at step 0)

(9) Total scan line time, 25.6 sec

18.3.2.8 Data-taking Sequence

The MSU data-taking sequence derives directly from the 11 Earth views, the cold-space view, and the microwave target view described in para 18.3.2.7. At each of the data-taking positions, the following information is digitized and shifted into a 128-bit register:

(a) One engineering word (telemetry voltage)

(b) Two temperature sensor outputs

(c) Four instrument data channel outputs

(d) Scan position angle

The A/D converter is a 12-bit unit. Four additional bits are added to each word for identification, making each word 16 bits long. The total number of words output each scan step is eight, which during normal scans require 1.893 sec. During this period there are approximately 19 TIROS Information Processor (TIP) frames output, each having slots for two MSU digital A words, or a total of almost 38. Since during most of this period there is no MSU data available, the TIP will receive and put out words filled with zeros. To identify "real words" from all zero-fill words, the Most Significant Bit (MSB) is 1 for all real words.

Once the MSU digital-A data words have been recovered from TIP and all-zero words stripped out, the remaining real words can be formatted into 8 by 14 word matrices, for each 25.6-sec MSU scan period, with one 8-word row corresponding to each sampling period. This matrix is illustrated in Figure 18.3-7.. The MSU word structure is shown in Figure 18.3-8.. As is noted in the scan position column, 3 bits are used to identify the number of scan cycles since the last 128-sec sync pulse. This is necessary since the MSU has a scan cycle time of 25.6 sec rather than the major frame time of 32.0 sec. The count is set to zero with the 128-sec sync, and counts each scan cycle up to four and is then reset to zero. Time synchronization of the MSU data with the spacecraft major frame is thus obtained.

0 INST SER NO: INDEX	1 T_1 CAL LO	2 T_2 CAL LO	3 CH 1 DATA	4 CH 2 DATA	5 CH 3 DATA	6 CH 4 DATA	7 SCAN POS. 0 SCAN COUNT
8 E CAL LO	T_1 CAL HI	T_2 CAL HI					15 SCAN POS. 1- SCAN COUNT
16 E CAL HI	ORTH 1 TEMP CH 1-2	ORTH 2 TEMP CH 3-4					23
24 XTAL CH 1+	L.O. CH 1 TEMP	L.O. CH 2 TEMP					31
32 XTAL CH 1−	L.O. CH 3 TEMP	L.O. CH 4 TEMP					39
40 XTAL CH 2+	DICKE LOAD CH 1 TEMP	DICKE LOAD CH 2 TEMP					47
48 XTAL CH 2−	DICKE LOAD CH 3 TEMP	DICKE LOAD CH 4 TEMP					55
56 XTAL CH 3+	TARGET 1A TEMP CH 1-2	TARGET 1B TEMP CH 1-2					63
64 XTAL CH 3-	TARGET & P CH 3-4	TARGET 2B TEMP CH 3-4					71
72 XTAL CH 4+	ANT 1 BEARING TEMP CH 1-2	ANT 2 BEARING TEMP CH 3-4					79
80 XTAL CH 4−	MOTOR TEMP	ENCODER TEMP					87
88 +5 VOLTS	R.F. CHASSIS TEMP -Z -Y	R.F. CHASSIS TEMP -Z +Y					95
96 E ZERO	PROG TEMP +Z +X	PROG TEMP −Z -X					103 SCAN POS. 12− SCAN COUNT
104 +5 VOLTS	105 PROG TEMP -Z +Y	106 PROG TEMP −Z -Y	107 CH 1 ZERO	108 CH 2 ZERO	109 CH 3 ZERO	110 CH 4 ZERO	111 CH POS X- SCAN COUNT

Figure 18.3-7. MSU Digital-A Telemetry

MSB															LSB
1	I	0	Z	D^{11}	D^{10}	D^9	D^8	D^7	D^6	D^5	D^4	D^3	D^2	D^1	D^0

D = DATA
Z = 1 WHEN IN ZERO REFERENCE DISABLE MODE
I = 1 FOR FIRST WORD OF SCAN

TYPICAL ALL WORDS EXCEPT SCAN POSITION – LINE COUNT

MSB															LSB
1	I	1	Z	S	R^2	R^1	R^0	E^7	E^6	E^5	E^4	E^3	E^2	E^1	E^0

E = SCAN ANGLE
R = SCAN LINE COUNT (RESET BY 128 sec SYNC)
S = 1 WHEN IN SCAN DISABLED MODE
Z = 1 WHEN IN ZERO REFERENCE DISABLE MODE

SCAN POSITION – LINE COUNT

Figure 18.3-8. MSU 16-bit Word Format

18.3.2.9 MSU Data

The output data signals supplied by MSU (to TIP) are of three types. In addition to the digital-A data, as described in para 18.3.2.8, there are analog and digital-B data.

18.3.2.9.1 Digital-A Data-The digital-A data, as illustrated in Figures 18.3-7 and 18.3-8 are arranged within an MSU frame as shown in Figure 18.3-9.

18.3.2.9.2 Analog Data-The analog telemetry points provided by the MSU are shown in Table 18.3-3. Detailed descriptions of each telemetry point are as follows:

(a) Channel-1 Output-Voltage proportional to Channel-1 radiometric temperature.

(b) Channel-2 Output-Voltage proportional to Channel-2 radiometric temperature.

(c) Channel-3 Output-Voltage proportional to Channel-3 radiometric temperature.

(d) Channel-4 Output—Voltage proportional to Channel-4 radiometric temperature.

(e) Calibration Target No. 1 Temperature-Sensor located in the Channel-1 and -2 calibration target.

(f) Calibration Target No. 2 Temperature-Sensor located in the Channel-z and -4 calibration target.

(g) Reference Load No. 1 Temperature-Sensor on the Channel No. 1 Dicke load.

(h) Reference Load No. 2 Temperature—Sensor on the Channel No. 3 Dicke load.

(i) Antenna Position-Voltage from shaft angle potentiometer which is proportional to shaft angle.

(j) Analog Reference-Monitor of excitation voltage for analog sensors Channels 5 through 9.

WORD 0, 8, 16 . . . 104	INSTRUMENT VOLTAGES
WORD 1, 9, 17. . . 105	INSTRUMENT TEMPERATURES
WORD 2, 10, 18 . . . 106	INSTRUMENT TEMPERATURES
WORD 3, 11, 19 . . . 107	CHANNEL 1 DATA
WORD 4, 12, 20 . . . 108	CHANNEL 2 DATA
WORD 5, 13, 21 . . . 109	CHANNEL 3 DATA
WORD 6, 14, 22 . . . 110	CHANNEL 4 DATA
WORD7, 15, 23 . . . 111	SCAN POSITION -- LINE COUNT

Figure 18.3-9. MSU Digital Format

TABLE 18.3-3. MSU ANALOG TELEMETRY

No.	Telemetry Point Name	S/C Chan. No.	Range	Resolution
1	Channel-l Data	317	0 -350 K	70°K/Volt
2	Channel-2 Data	327	0 -350 K	70°K/Volt
3	Channel-3 Data	365	0 -350 K	70°K/Volt
4	Channel-4 Data	373	0 -350 K	70° K/Volt
5	Cal. Target #1 Temp	182	-30 to +50°C	16°C/Volt
6	Cal. Target #2 Temp	190	-30 to +50°C	16°C/Volt
7	Ref. Load #1 Temp	198	-10 to +50°C	12°C/Volt
8	Ref. Load #3 Temp	206	-10 to +50°C	12°C/Volt
9	Antenna Position	349	0 to 350°	70° /Volt
10	Analog Reference	381	0 to 5 Volt	W - W - -

NOTE: MSU analog telemetry sampling period is 32 sec.

18.3.2.9.3 Digital-B Data-The digital-B telemetry points provided by the MSU are shown in Table 18.3-4. Detailed descriptions of each telemetry point are as follows :

(a) Data Systems-The data system telemetry point is connected to the power supply. A positive voltage on this point indicates that power relay switch closure has occurred, applying power to the data system power supply input. This system must be powered before data can be obtained from the output.

(b) Channel l-Positive voltage on this telemetry point indicates power relay switch closure and application of power to the Channel-l power supply .

(c) Channel Z-Positive voltage on this telemetry point indicates power switch closure and application of power to the Channel-2 power supply.

(d) Channel 3-Positive voltage on this telemetry point indicates power switch closure and application of power to the Channel-3 power supply.

TABLE 18.3-4. MSU DIGITAL-B TELEMETRY

No.	Telemetry Point Name	S/C Chan. No.	State*	
			Logic "1"	Logic "0"
1	Data System	184	OFF	ON
2	Channel 1	216	OFF	ON
3	Channel 2	248	OFF	ON
4	Channel 3	25	OFF	ON
5	Channel 4	57	OFF	ON
6	Scan Power	89	OFF	ON
7	System Reset/Scan Enable	121	ENABLE	RESET
8	Reference Position Enable	153	DISABLE	ENABLE

NOTE: Repetition rate of digital-B telemetry is 3.2 sec.

(e) Channel I-Positive voltage on this telemetry point indicates power switch closure and application of power to the Channel-4 power supply.

(f) Scan Power-Voltage on this telemetry point indicates power relay switch closure and application of power to the scan power supply.

(g) System Reset/Scan Enable-This telemetry point indicates the status of instrument logic, which determine whether the instrument is in scan mode (SCAN ENABLE) or scan stop and reset mode (SCAN DISABLE). Spacecraft and instrument logic is set to provide 0 volt to indicate scanning operation. A scanning condition will be indicated by a varying voltage from the analog scan angle indicator.

(h) Reference Position Enable/Disable-This telemetry point indicates the status of instrument logic which determines mode of REFERENCE POSITION. Normal scanning operation requires that the reference position be enabled (5-V telemetry output). The instrument will scan with REFERENCE POSITION in DISABLED but will not automatically assume a normal antenna position. REFERENCE POSITION ENABLED will be indicated by automatic phasing of the antenna position with respect to 0 position as indicated by scan angle telemetry.

18.3.3 MODES OF OPERATION

18.3.3.1 Prelaunch and Launch Mode

There is no particular prelaunch mode requirement for the subsystem as long as whatever configuration is used is made known to the Activation and Evaluation (A&E) personnel. In the launch mode all power supplies and assemblies of the MSU are to be off, with the antenna stepped to position 33 in order to lessen the effect of vibration in the launch vector. Prior to launch the MSU will be exercised according to plan and verified ready for launch with the successful performance of the system electrical performance tests. After these tests are completed, the antenna will be put into the stepped mode, stepped to position 33, and then all supplies and assemblies turned off. Position 33 is 180 deg from the space-view position.

18.3.3.2 Orbit Mode

For the MSU there is no particular decontamination mode. This unit will simply be left in the launch mode to outgas for a short period (one or more days) and then put into the normal orbit mode. The only constraint is that in turning on the subsystem, the data system power supply must be turned on first. The MSU can be operated in the orbit mode at full capacity (all four channels) or at a reduced capacity (fewer than four channels), determined by operational needs to conserve power or because of failure within one or more channels.

18.3.3.3 Standby Mode

This mode is simply a low-power mode to conserve spacecraft power in the event of problems within some other subsystem of the spacecraft. In this mode, all power supplies and assemblies are turned off until the contingency condition is over. The only constraint is that the data system power supply be turned off last.

18.3.3.4 Reset Mode

In this mode, the antenna is inhibited from its normal scan sequence and reset to the zero position. From there it can be manually stepped to any position desired, where it will remain until commanded further. This mode can be used in case of impending failure of the scan system to allow some data to be taken.

18.3.4 CONSTRAINTS

There are few constraints concerning operation of the MSU. Among these are:

(a) The data system power supply must be on before assemblies are enabled.

(b) Before the data system power supply is turned off, all other assembly supplies must be off.

(c) The antenna should be in position 33 during the launch phase.

(d) Two seconds should be allowed between the executions of consecutive MSU commands.

18.4 STRATOSPHERIC SOUNDING UNIT (SSU)

18.4.1 FUNCTIONAL DESCRIPTION

18.4.1.1 Introduction

The purpose of the Stratospheric Sounding Unit (SSU) is to measure the atmosphere's temperature distribution in the upper stratosphere (between 25-km and 50-km altitude) with as near-global -coverage as is possible from each day of satellite operations. The SSU measurements will be made with a vertical resolution of about 10 km and a horizontal resolution along the subpoint track of about 150 km. particular scientific objectives are to:

(a) Monitor the atmosphere's mean structure and the changes which occur with latitude and season in the 25-km to 50-km altitude range.

(b) Investigate the propagation of large-scale atmospheric waves (especially stratospheric warmings) at this altitude and to determine to what extent these disturbances are generated in the mesosphere.

(c) Investigate links between ionospheric phenomena and the CO2 circulation produced by upper atmospheric winds.

18.4.1.2 Basic Onerational Theorv

In order to interpret infrared radiation received at the satellite in terms of a temperature profile, both the absolute intensity and some method of identifying the effective height range of the emission is required. Carbon dioxide is chosen as an emitter since it is uniformly mixed within the atmosphere and has a convenient (reasonably isolated) spectral band at 15 μm. A well defined height range – a narrow weighting function – requires selection of energy originating within a narrow range of absorption coefficients; ideally this would be part of a spectral lin The actual value of the absorption coefficient determines the effective height of the emission; for strong absorption the received energy comes from high in the atmosphere; less strong -- lower in the atmosphere.

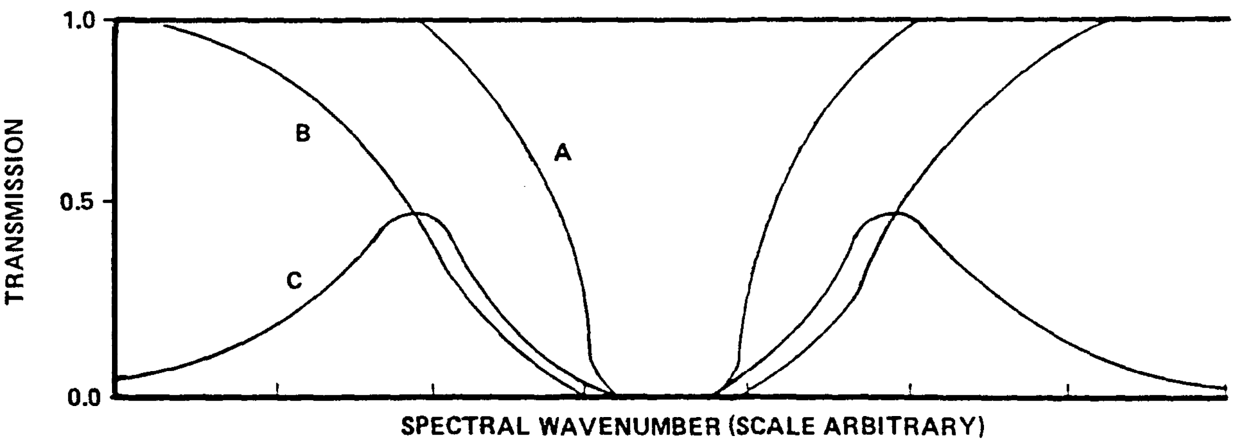
For a practical radiometer the energy grasp of the system must be increased to provide a useful signal to noise ratio. Hence a comb filter is needed to selectively add together the chosen narrow spectral intervals. Such a filter which exactly matches the CO_2 emission spectrum is most readily engineered by introducing a cell containing CO_2 within the radiometer optics chain.

Figure 18.4-1 illustrates the effect of modulating the pressure in such a cell (with a mean pressure of 11 millibar channel 27). Here the difference plot C is one bi-tooth of a multitooth comb filter. A bandpass filter reduces the sensitivity of the system to step changes in broadband background changes, while accepting ~/100/such teeth. The other 2 channels work in a similar way. With a higher mean cell pressure the positions of the curves C have increased in separation while remaining symmetrical about the spectral line. A lower absorption coefficient region is thus selected with a consequentiallowering of the weighting function.

An added bonus of this selective chopping technique is the reduced sensitivity to other infrared emitters – eg. ozone and water vapor. This is because although both molecules have spectral lines within the bandpass of the filter, these lines in general do not match the teeth of the comb filter and hence are not modulated by the comb filter and consequently are not detected by the phase sensitive detection system.

18.4.1.3 Basic Configuration Description

The SSU is a three-channel, cross-course scanning radiometer. Measurements are in a step-scan pattern covering 40 deg on each side of nadir with an instantaneous Field-Of-View (FOV) of 10 deg. The spectral characteristics of each channel is determined by a CO2 gas cell in the optical path. Modulation is achieved by sinusoidally changing the pressure in the cell; the amount of CO2 gas in the cell determines this frequency of modulation. Behind each CO2 cell is a bandpass filter and a light pipe which converges the radiation onto a pyroelectric detector. A scan mirror is employed to achieve a stepped scan. The scan logic program provides for housing reference blackbody looks and space looks to obtain a two-point, in-flight calibration. The scanned area



NOTE

A ≡ 8 millibar curve

B ≡ 14 millibar curve

C ≡ Effective transmission for modulated signal generated by differencing B and A

Figure 18.4-I. Illustrative Plot of Transmission of a 1 cm Cell for Two Different Cell Pressures (for a Representative Spectral Line). (These curves approximate to V5 channel 27.)

begins 40 deg to the left of the satellite subtrack and continues to 40 deg to the right of the subtrack (see Figure 18.4-2). The scan pattern consists of a repetitive transverse scan containing eight FOV elements. An observation area adjacent to the suborbital track has near-circular surface dimensions of 146 km while observations at the outer edge of the scan have surface dimensions determined by a distorted ellipse of approximately 244 km by 186 km.

18.4.1.4 Data Products

The data system for the SSU consists of circuitry to output all of the radiometric data, essential telemetry, and general status information. All of this information is transferred via the spacecraft TIROS Information Processor (TIP) and will be available wherever TIP data are available. The SSU data system will utilize TIP digital-A, digital-B, and subcommutated analog channels.

18.4.1.4.1 Digital-A-The SSU is designed to output all digital instrument data to the TIP digital-A channels. These data include all radiometric signals, instrument temperatures, status monitors, and any other critical telemetry required for utilization of the radiometric data.

18.4.1.4.2 Digital-B-The digital-B or bilevel telemetry consists of the four single-bit status monitors used essentially for command verification. The sample rate of each of the four allotted bilevel channels will be once every 3.2 sec

18.4.1.4.3 Subcommutated Analog Telemetry-These 10 telemetry channels are intended for instrument use to monitor critical temperatures, particularly when the instrument is off, (for example, during the launch phase) and to monitor converter voltages for diagnostic purposes.

18.4.1.4.4 Data Storage-There is no onboard data storage required by the SSU

18.4.2 SYSTEM DESCRIPTION

18.4.2.1 General

The SSU system is functionally similar to the Pressure Modulator Radiometer (PMR) system flown on Nimbus 6. The SSU incorporates three pressure-modulated infrared channels as its radiometric inputs. This instrument is a scanning radiometric sounder utilizing a rotating mirror to accomplish scanning and using the pressure-modulated gas (C02) to accomplish selective band-pass filtration of the sampled radiances. The gas is of a pressure chosen to yield weighting functions peaking in the altitude range of 25 to 50 km and is contained

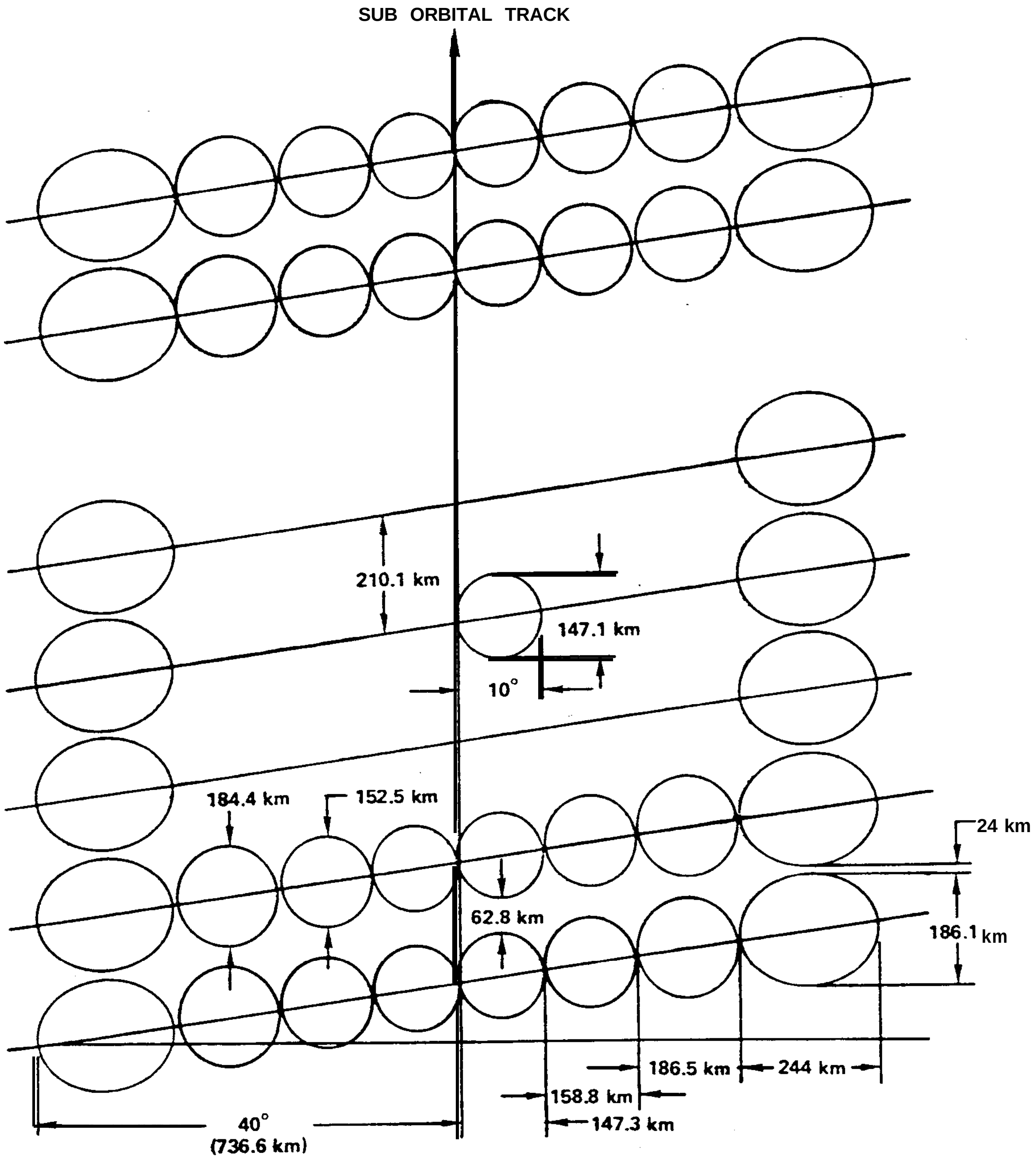


Figure 18.4-Z. SSU Scan Pattern

in cells located in the optical paths of the three parallel imaging assemblies. Each of these assemblies utilizes (in addition to its respective gas cell) lenses, filters, a conical light pipe, and a detector. The view of the three assemblies is step-scanned cross track by a rotating elliptical plane-mirror driven by a geared stepper motor assembly. This results in a ± 40 deg *scan* consisting of eight 1 O-deg steps, each requiring 4 sec (0.4-sec step and settle time, and 3.6-sec measuring and integrating time). The resultant radiant energy detected by the three channels during these times is then, after integration, sampled, digitized, and shifted to the TIP at the proper time in the form of 16-bit digital-A words, of which 12 bits are used.

A summary of SSU requirements is given in Table 18.4-l) and radiometer performance specifications are given in Table 18.4-2. Figure 18.4-4 is the system block diagram, and Figure 18.4-5 illustrates the system itself. The SSU can be broken down into the following major assemblies which together form the complete unit. They are as follows:

(a) Scan assembly.

(b) Pressure Modulator Cell (PMC) assembly.

(c) Optics assembly.

(d) Electronics assembly.

18.4.2.2 Scan Assembly

The scan assembly consists of a 90-deg stepper motor driving a single pass 9-to-l reduction gear assembly for a step angle of 10 deg. Five magnetic reed switches plus a Light Emitting Diode (LED) and a detector for a fine position indicator are fitted into the bearing housing and are operated by a magnet carried in a nylon gear. The switches will give an indication of the Position at the two extremes of the Earth-scan view, at Earth-scan position No. 5, and at space and calibration blackbody position.

18.4.2.3 Pulse Modulator Cell

The PMC (Figure 18.4-3) contains a drive system consisting of a coil and magnet used to oscillate a piston within a cylindrical bore to produce the required pressure modulation. A suspension system of two-plane, spiral-cut springs support the piston shaft. The PMC 's are operated at their natural resonance frequencies as set mainly by the restoring force arising from the springs and compressed gas.

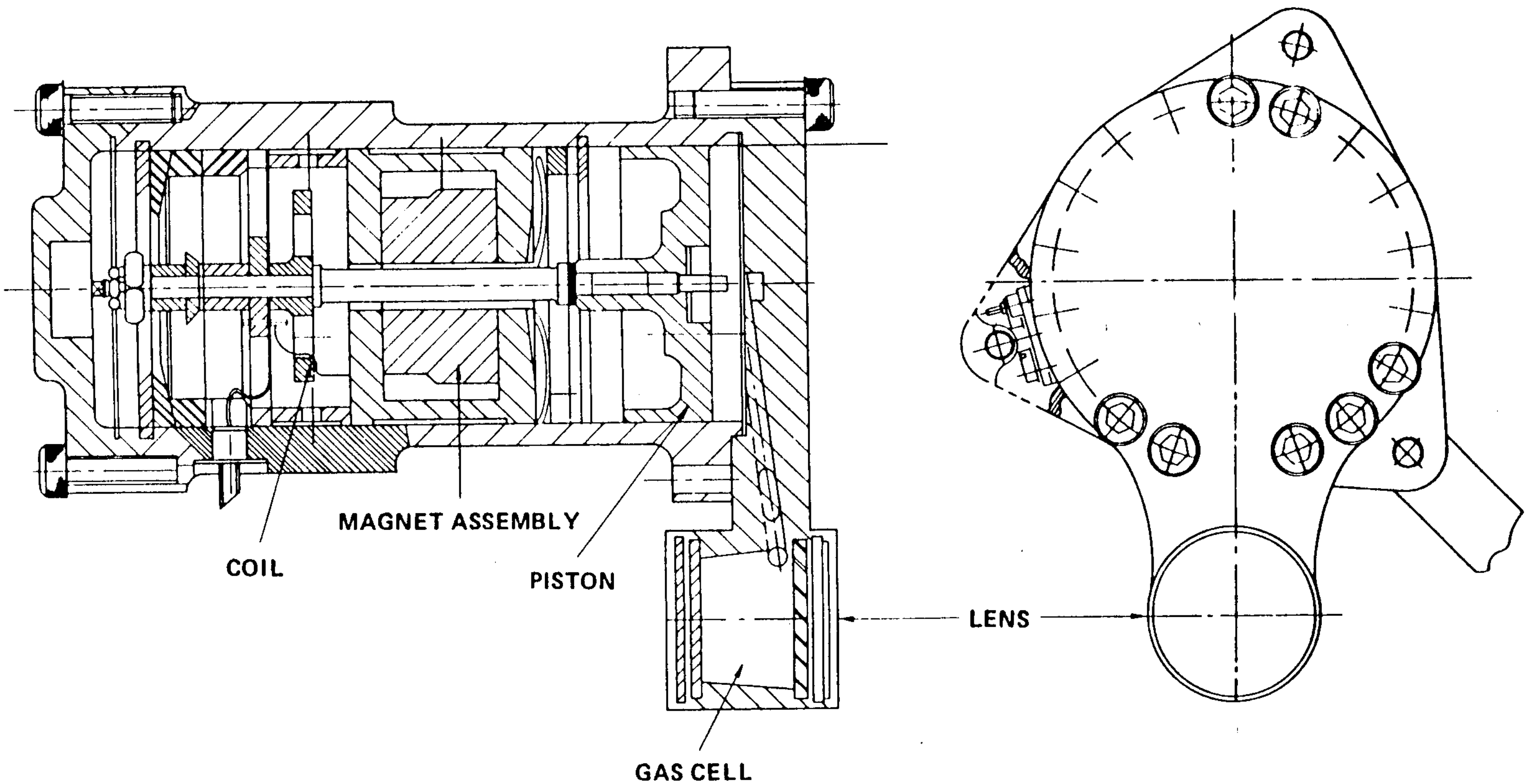


Figure 18.4-3. SSU Pressure Modulator Cell

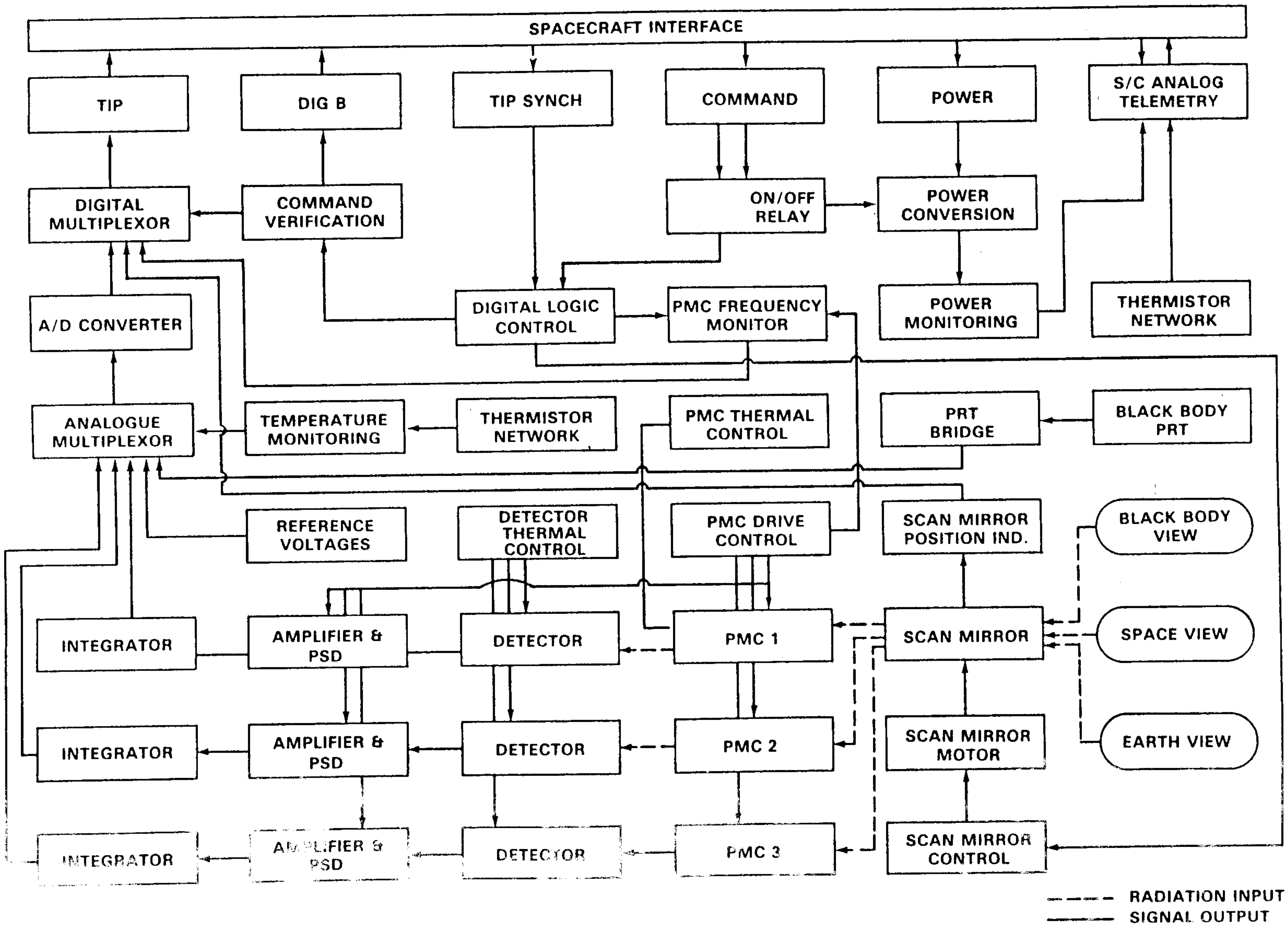


Figure 18.4-4. Block Diagram Stratospheric Sounding Unit

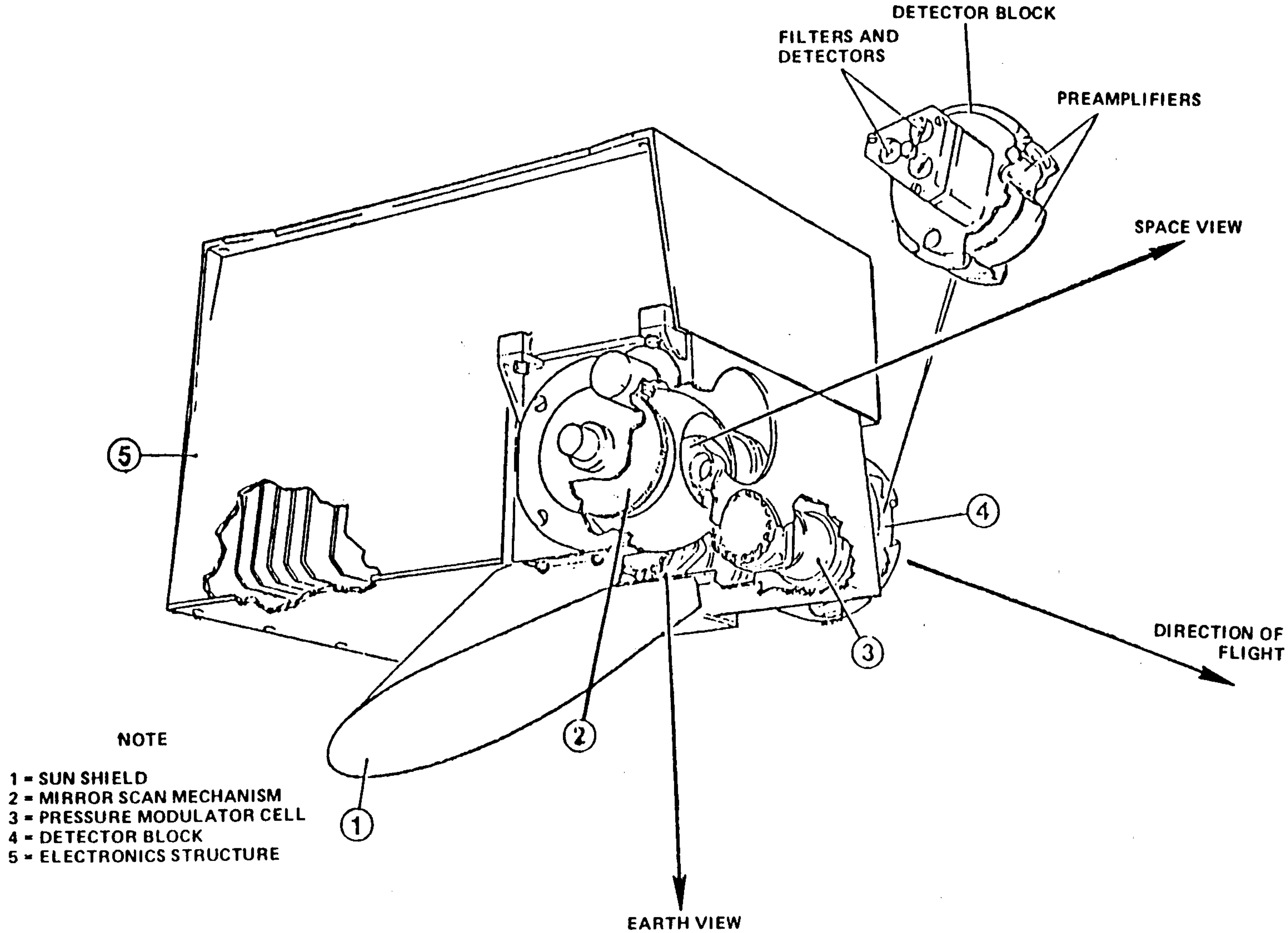


Figure 18.4-5. The Complete SSU, Showing the Views to Earth and to Space

TABLE 18.4-I. SSU PERFORMANCE REQUIREMENTS

Parameters	Channel 1	Channel 2	Channel 3
Nominal pressure at peak of weighting function	15	5	1.5 mb
Noise equivalent temperature difference at scene temperature of: $0^{o}C$ ($273^{o}K$)	<0.25*	<0.5*	<$1.25^{o}K$*
-600C ($213^{o}K$)	<0.5* *	<1.0*	<$2.5^{o}K$*
Noise equivalent radiance	<0.35**	<0.7**	<1.75**
Bias error between deduced temperature and scene temperature	<$1^{o}K$***	<$1^{o}K$***	< $1^{o}K$***
Bias error between any two SSU channels	<$0.5^{o}K$	<$0.5^{o}K$***	<$0.5^{o}K$***
Angular diamter of FOV	10 deg	10 deg	10 deg
Relative alignment of channels	0.5 deg	0.5 deg	0.5 deg
Number of earth views	8	8	8
Time interval between scan-mirror steps	4 sec	4 sec	4 sec
Total extent of scan, either side of nadir	40 deg	40 deg	40 deg

NOTE

* The design aim is to achieve performance a factor of two better than this requirement.

** These noise equivalent radiances (mW/m^2 steradians cm^{-1}) are consistent with the quoted NE AT values.

*** For scene temperatures between 200 and $300^{o}K$.

TABLE 18.4-2. SSU RADIOMETER PERFORMANCE SPECIFICATIONS

Performance	Channel 1	Channel 2	Channel 3
Spectral range (cm^{-1})	668	668	668
Equiv. bandwidth (cm^{-1})	2.0	1.0	0.4
Detector	TGS pyroelectric	TGS pyroelectric	TGS pyroelectric
Resolution (km at nadir)	147.3	147.3	147.3
IFOV (deg) circular	10^0	10^0	10^0
NE ΔT @ 273^0K	0.125	0.25	0.625
NER	0.375	0.375	0.375
Weighting function peak (Atmospheric pressure in mb)	15	5	1.5

18.4.2.4 Optics Assembly

The optics assembly (for each channel) consists of the scan mirror (also part of the scan assembly), telescope, a light pipe, interference filters, and the corresponding PMC which acts as a variable band-reject filter to the incoming radiances. These are illustrated together in Figure 18.4-6.

18.4.2.5 Electronics Assembly

General description on electrical system. For information refer to Figure 18.4-7.

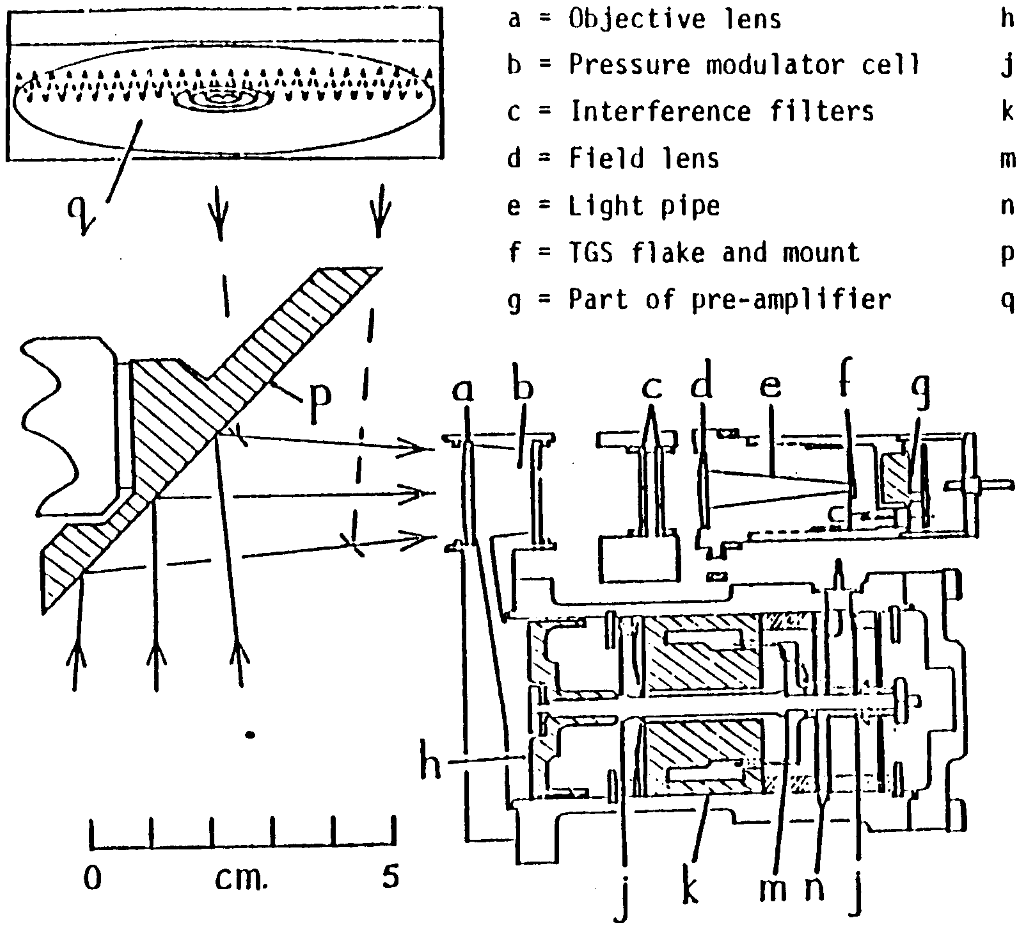
Each of the 3 signal channels consists of detector, preamplifier, test input to inhibit signals after the preamplifier, main amplifier, inverter and phase sensitive detector (PSD). The PSD is switched by reference signals from the relevant PMC. The rectified signal then passes to an integrator, integrating for approximately 3.6 seconds in every 4 seconds. The integrator has an offset to permit output from the full range of expected scene temperatures to cover 20% to 80% of the telemetry range.

Each PMC amplitude is monitored by the back e.m.f. generated in the coil and is controlled by varying the drive pulse width. Amplitude information is fed to the spacecraft telemetry. The back e.m.f. also generates a reference signal for the signal channel PSD and also an input to the frequency counter. The counter counts the oscillations of one PMC over a 32 second period and presents the total to the data handling logic for inclusion in the digital 'A' output. After this, the second PMC's oscillations are counted for 32 seconds, followed by those of the third PMC.

The calibration scan mirror is rotated by a 4 pole stepper motor driven by pulses derived from the SSU main counter. Mirror position is sensed by 5 magnetic reed switches which sense 5 of the possible mirror views. One reed switch is used to synchronise the mirror to its drive logic, and to supply digital position telemetry.

All Analogue signals are multiplexed together and fed to a 12 bit dual range analogue to digital converter. The digital output is then multiplexed with other digital information such as command status, mirror position, PMC frequency and data frame identification in a digital multiplexer controlled by the data handling logic.

The SSU contains a dcdc converter to supply secondary power, from the main spacecraft power bus of +28V to much of the electronics. The power converter provides ground isolation for the secondary power.



a = Objective lens
b = Pressure modulator cell
c = Interference filters
d = Field lens
e = Light pipe
f = TGS flake and mount
g = Part of pre-amplifier
h = Piston
j = Three-arm diaphragm support springs
k = Magnet assembly
m = Drive coil
n = Single-arm conductor springs
p = Scan mirror
q = Internal blackbody

Note

In practice the scan mirror and blackbody are shared by three optical channels.

Figure 18.4-6. Layout of One Channel of the SSU Radiometer

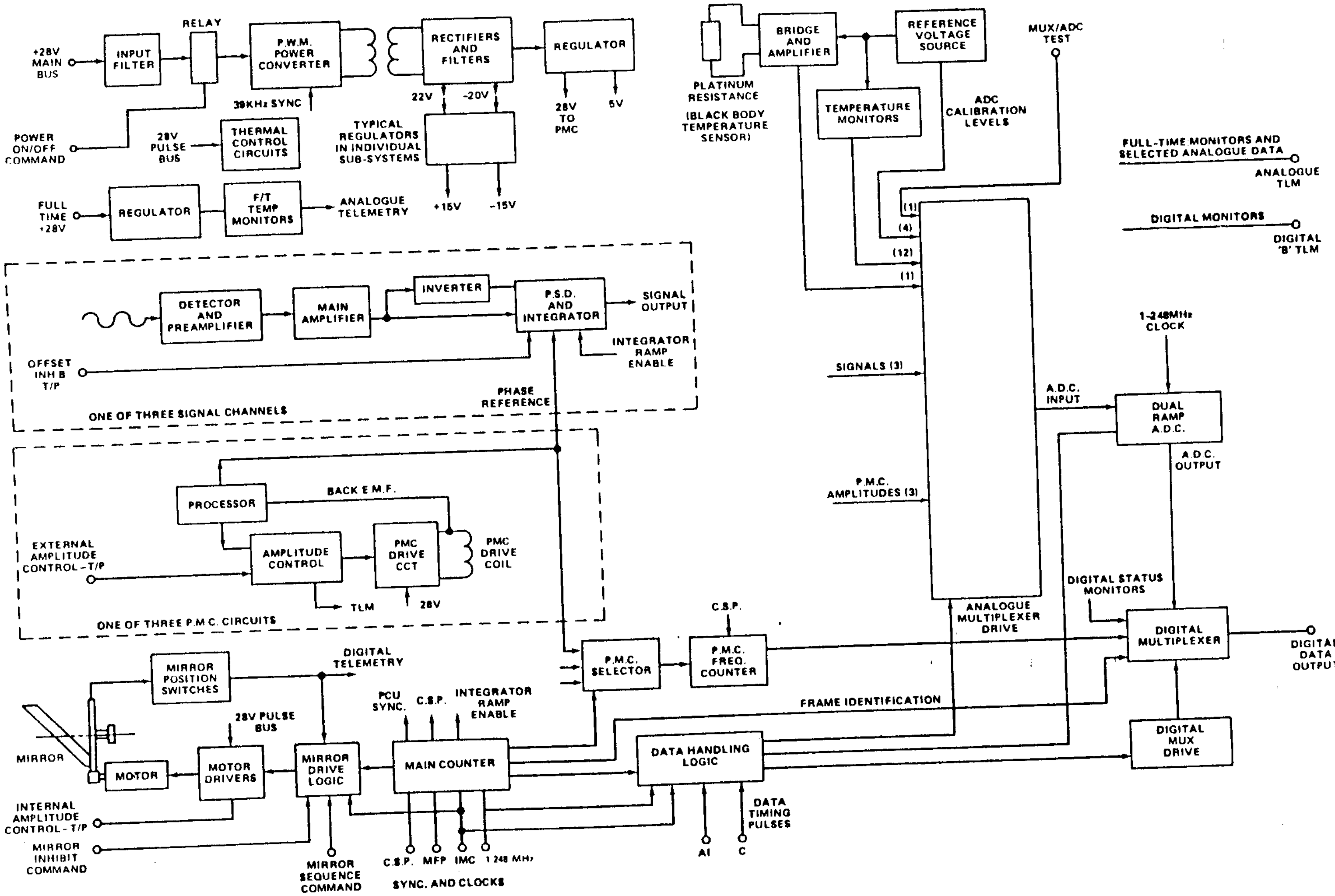


Figure 18.4-7. S.S.U. Electrical Block Diagram

18.4.2.6 SSU Calibration and Radiance Processing

Each output ramp from the three signal integrators are sampled eight times. In practice these ramps are characterized by their (8-l) values (sometimes if the first value is zero then a rescaled (8-2) is used). Thus a counts value X may be obtained every four seconds.

A SSU calibration cycle takes place during the first 32 seconds in each major frame (256 seconds apart). The mirror is stepped to view space then inhibited for 16 seconds, this is followed by stepping to view the Black Body target for the remaining 16 seconds. Mean values of counts X_{SP} (space) and XBB (Black Body) may then be obtained in subsequent ground processing. Using the house keeping data from the platinum resistance thermometer the black body radiance is calculated using the Planck function $R = p/(\exp^{Q}/T - 1)$ where T is the black body temperature in degrees Absolute and P and Q are as follows:–

	Channel 25	Channel 26	Channel 27	Units
P	3582.093	3576.322	357 1.982	$MW/(M^2\ sr\ cm^{-1})$
Q	964.00 1	963.483	963.093	$K^{-1}m$

The equation for earth view radiance R_{EA} is then given by $R_{EA} = aX_{EA} + b$ where $a = (R_{SP} - R_{BB})/(X_{S\bar{P}} - XBB)$ and $b = (X_{S\bar{P}}\ RBB - XBB\ R_{SP})/(X_{S\bar{P}} - XBB)$, where $X_{\bar{S}P}$, the 'true' space view counts = XSP + AXINH.

During the first 16 seconds of each calibration cycle the Black body platinum thermometer is switched out of circuit and a calibrating resistor is introduced. However when an Inhibit in Space test is carried out it is found that the space counts for the calibration cycle differ from those measured during the normal black body and earth views. Such Inhibit in space tests are carried out at three monthly intervals. The correcting values obtained are referred to a "space offsets" and are applied to the space counts encountered during normal operation. The values for NOAA 6 and 7 are given below, as examples: –

	Values of	for NOAA 6 and NOAA 7		
	Channel 1	Channel 2	Channel 2	Units
NOAA 6	+15	+3	-13	Counts
NOAA 7	+ 3	+o	+ 6	Counts

Prelaunch calibration tests have demonstrated that the linear equation given above is correct within the instrument specification.

18.4.2.7 SSU Data

The data system for SSU consists of circuitry to output all of its radiometric data, essential telemetry, and general status information to TIP. The SSU shall use TIP digital-A, digital-B, and subcommutated analog data channels.

18.4.2.7.1 Digital-A-The SSU outputs a full SSU frame of digital-A data every second (every 10 TIP frames). This SSU frame, which is thirty 16-bit words in length, outputs at a rate of three words each TIP frame (encompassing six TIP word locations: 16 and 17, 32 and 33, and 76 and 77). The content of the data in the SSU frame is shown in Tables 18.4-3 and X3.4-4; the general organization is shown in Figure 18.4-8 ; and the location within the TIP frame is shown in Figure 18.4-9. In general, four digital-A SSU frames are sent to TIP during each 4-sec step interval (going into 40 TIP frames). During this interval all data are repeated three times. Since the radiometric data consist of eight consecutive samples of the integrators, the cycle is once per four sec. Each SSU word requires 12 of the 16 available bit locations, thus resulting in four fill bits in each word.

18.4.2.7.2 Digital-B—The digital-B or bilevel telemetry consists of single bit status monitors used essentially for command verification. The sample rate is once every 3.2 sec. The SSU digital-B functions are given in Table 18.4-5.

18.4.2.7.3 Subcommutated Analog Telemetry—These telemetry channels are intended for instrument use to monitor critical parameters used for the determination of correct instrument operation and for diagnostic purposes. The SSU analog functions are given in Table 18.4-6.

TABLE 18.4-3. DIGITAL-A WORD CONTENT

SSU Format Location	Title	Minor Frame Number	Minor Frame Word Number
CA1	Digital word 1 (see table 2-4)	0, 10. . .310	16-17
CA2	Digital word 2 (see table 2-4)	0	32-33
CA3	Digital word 3 (see table 2-4)	0	76-77
CA4	Space port temp.	1	16-17
CA5	Earth port temp.	1	32-33
CA6	PMC bulkhead temp.	1	76-77
CA7	Detector temp. (separate sensor for analog)	2	16-17
CA8	Blackbody temp. (space side)	2	32-33
CA9	Blackbody temp. (sun side)	2	76-77
CA10	Cell temp. Ch 1	3	16-17
CA11	Cell temp. Ch 2		32-33
CA12	Cell temp. Ch 3	3	76-77
CA13	Baseplate temp.	4	16-17
CA14	Middle blkd. temp.	4	32-33
CA15	Optics baseplate temp.	4	76-77
CA16	Signal output Ch 1	5	16-17
CA17	Signal output Ch 2	5	32-33
CA18	Signal output Ch 3	5	76-77
CA19	Thenistor reference	6	16-17
CA20	Mirror fine position	6	32-33
CA21	Blackbody temp. (Pt)*	6	76-77
CA22	PMC amplitude Ch 1	7 A function of	16-17
CA23	PMC amplitude Ch 2	7	32-33
CA24	PMC amplitude Ch 3	7 PMC pressure	76-77
CA25	ADC calibration 5% of full scale	8	16-17
CA26	ADC calibration 50% of full scale	8	32-33
CA27	ADC calibration 95% of full scale	8	76-77
CA28	Signal output Ch 1	9	16-17
CA29	Signal output Ch 2	9	32-33
CA30	Signal output Ch 3	9, 19. . .319	76-77

NOTE

After the 12th bit has been transmitted, the D1 data line will return to its high or "OFF" state.

* When looking at space, a fixed resistor is inputted. Switchover is at 16 seconds into calibration cycle.

TABLE 18.4-4. CONTENT OF SSU DIGITAL WORDS 1, 2, AND 3

Digital Word	Bit	Description	Logic 0	Logic 1
Digital word 1 (Digital A words Nos. 16 and 17)	1-11	11-bit frame identity, cycle time = 2048 sec	-	-
	12	Mirror sync, recovery status	Normal	Recovery
Digital word 2 (Digital A word Nos. 32 and 33)	1	Power ON/OFF command verification	OFF	ON
	2	Mirror inhibit ON/OFF command verification	OFF	ON
	3	Cal. rate auto (manual verification)	AUTO	MANUAL
	4**	Cal. verification (command verification only)	-	CAL.
	5	Mirror position space*	VALID	-
	6	Mirror position blackbody*	VALID	-
	7	Mirror position EA1*	VALID	-
	8	Mirror position EA5*	VALID	-
	9	Mirror position EA8*	VALID	-
	10***	Mirror position correct YES/NO*	YES	NO
	11	Modulator frequency channel identification	Low and High	Medium
	12	Modulator frequency channel identification	Low and Medium	High
Digital word 3 (Digital A word Nos. 76 and 77)	1-12	12-bit binary count of modulator frequency over a 32-second period. This is only active in the frame following each MFP, i.e., valid only in minor frame 0. Each channel is displayed in turn, one channel every 32 seconds. During the count period, bits 1 to 12 are logic 0.	-	-

NOTE

* The data in these positions is invalid during the first second after the mirror steps. Use data in minor frames 10 and on for valid indicators.

** Applicable only in the manual mode.

*** Bit 10 is not used because it is subject to error. CA 2 is used instead.

MINOR FRAME	TIP WORDS 6 – 17		TIP WORDS 32 – 33		TIP WORDS 76 – 77		TIME (Sec)
0	FRAME ID		DISCRETES		MDLR FREQ		0.1
1	SP PORT T		EA PORT T		PMC BKHD T		0.2
2	DETECT T		BK BDY T		BK BDY T		0.3
3	CH1 CELL T		CH2 CELL T		CH3 CELL T		0.4
4	BASE PLT T		MD BKHD T		OPT a PLT T		0.5
5	CH1 SIG		CH2 SIG		CH3 SIG		0.6
6	THERM REF		POS CORRECT		3B PRT T		0.7
7	CH1 PMC AMP		CH2 PMC AMP		CH3 PMC AMP		0.8
a	ADC 5%		ADC 50%		ADC 95%		0.9
9	CH1 SIG		CH2 SIG		CH3 SIG		1.0

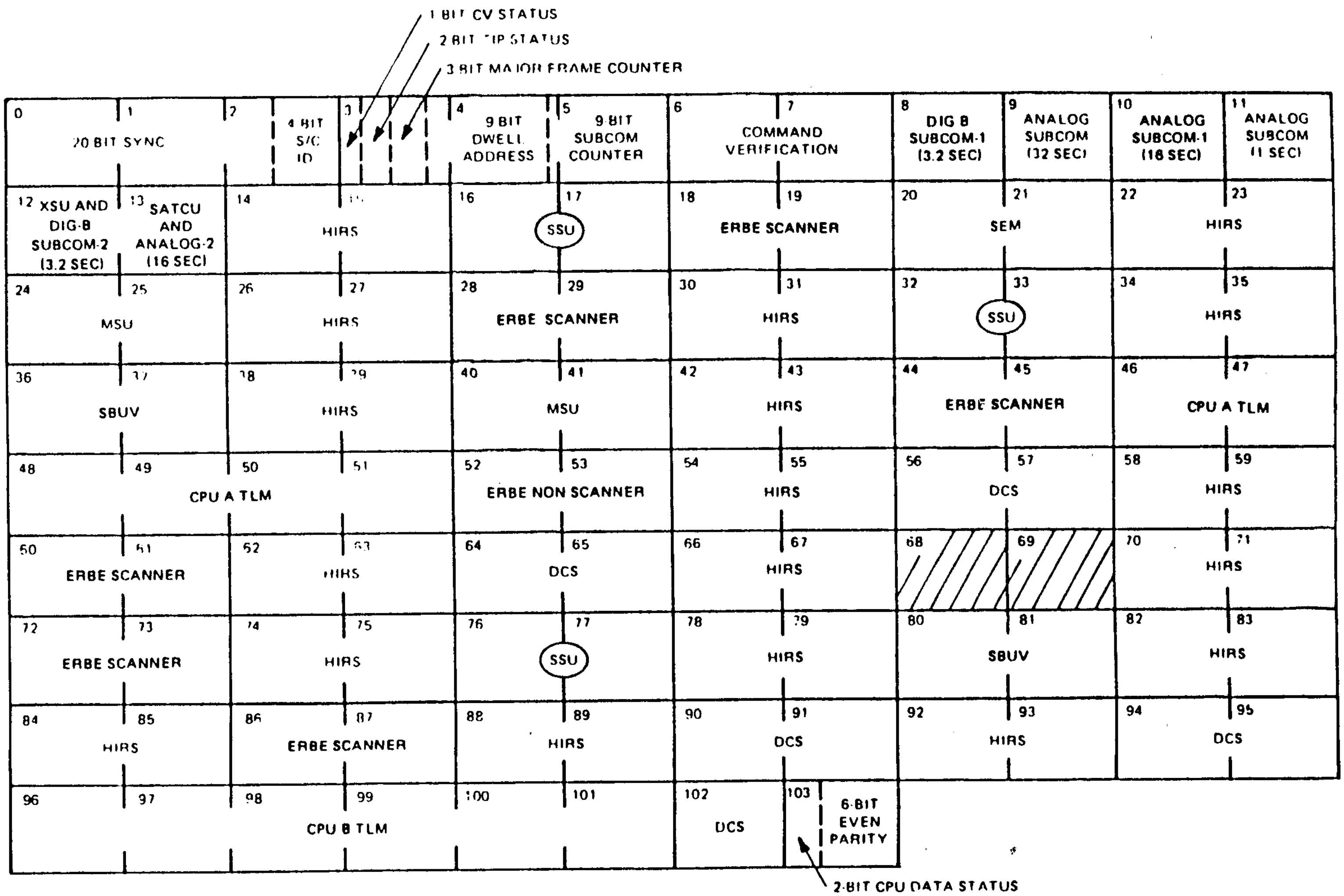
2^0 (SSU)

2^0 (TIP)

NOTE

Data is not right justified

Figure 18.4-8. SSU Frame Digital-A Data Format



NOTES 1) NUMBER IN UPPER LEFT-HAND CORNER INDICATES MINOR FRAME WORD NUMBER.
2) TIME CODE DATA APPEARS DURING MINOR FRAME "0" WORD LOCATIONS 8 THROUGH 12
3) ///// INDICATES SPARE WORD LOCATIONS, AND CONTAINS CODE 01010101.
4) MINOR FRAME PERIOD = 0.1 SECOND
MAJOR FRAME PERIOD = 32 SECONDS
OUTPUT DATA RAT[illegible] 8.3[illegible]

Figure 18.4-9. SSU Digital-A Word Locations in the TIP Orbital Mode Minor Frame Format

TABLE 18.4-5. SSU DIGITAL-B TELEMETRY

No.	Telemetry Point Name	Digital-B Channel Numbers	State	
			Logic 1	Logic 0
1	Power ON/OFF	5 6	OFF	ON
2	Mirror inhibit ON/OFF	88	ON	OFF
3	Calibration AUTO/MANUAL	120	MANUAL	AUTO
4	Manual calibration enabled YES/NO	152	YES	NO

NOTE

No Digital-B if SSU OFF.

Digital-B reflects instrument command status.

Upon receipt of manual Cal. enable command, channel 152 changes to logic 1. Return to logic 0 occurs at first MFP following a CSP.

18.4.3 MODES OF OPERATION

18.4.3.1 Prelaunch, Launch, and Off Modes

There is no particular prelaunch mode requirement for this subsystem with respect to Activation and Evaluation (A&E) as long as whatever configuration is used is known to A&E personnel. This configuration will generally be determined by prelaunch test requirements. In the launch mode all subassemblies of the SSU are to be off, with the mirror in the blackbody look position in order to lessen the effect of vibration along the launch vector. This is also defined as the off mode to be used in case of a subsystem failure during operation or in case of a spacecraft emergency. (This corresponds essentially to the inhibit mode for other subsystems.) Prior to launch, the SSU will be exercised according to plan and verified ready for launch with the successful performance of the system electrical performance tests. After these tests are completed, the mirror will be put into the blackbody look position and all subassemblies turned off. (The same turn-off procedure will be used during orbital operation.)

18.4.3.2 Evaluation and Mission Operation Modes

These comprise the various operating modes of the SSU and are all accessed from the off mode (described in para 18.4.3.1) in the same manner. The basic variances within these operating modes will be defined by the use of the calibration mode and mirror inhibit commands and will be dependent upon evaluation needs.

TABLE 18.4-6. SSU ANALOG TELEMETRY

No.	Telemetry	Channel Number	Equation	Nominal Value
1	Baseplate temp.	38	(TBD)	$15^oC \pm 10^oC$
2	Detector temp.	46		$25^oC \pm 0.5^oC$ for PF1 $30^oC \pm 0.5^oC$ for F2-F8
3	Scan mechanism temp.	54		$15^oC \pm 10^oC$
4	Analog reference supply	62		$4.5V \pm 0.2V$
5	+22V monitor	78		(TBD)
6	-20V monitor	86		(TBD)
7	+5V monitor	94		(TBD)
8	+28V secondary monitor	70		(TBD)
9	PCS temp.	166		$15^oC \pm 10^oC$
10	Electronics ref. volts	174		$5.0V \pm 0.1V$
11	TCE heater voltage	176		0V = disabled 2.5V = enabled full on 2.5V = enabled off
12	TCE louver voltage	184		0V = disabled 2.5V = enabled, full on 4.7V = enabled, off

NOTE

All analog telemetry from SSU appears in TIP 32-second analog subcom.

18.4.3.3 Inhibit Mode

This is essentially a transitional mode which is accessed in changing from one of the operation modes to an off mode and from off to an operational mode. (This should not be confused with the definition of inhibit mode for other subsystems.) In this mode the mirror is stopped at the appropriate time within the frame prior to turn off or started at the appropriate time after turn on. This time is generally during major frame 0, minor frame 1'70 to 280, during which the SSU is in the blackbody look position. However, for special evaluation requirements, other positions can be chosen. (Also, inhibit mode can, for special evaluation requirements, be accessed from an operational mode without continuing to the off mode.)

18.4.3.4 Mode Change Philosophy

The SSU is essentially a simple, flexible subsystem with few critical constraints on its modes of operation. Most modes can be accessed from any other without damaging the subsystem. Only the transition times (within a calibration cycle) need generally be carefully observed to assure proper pointing when inhibited or off. Figure 18.4-10 is a diagram illustrating state parameters involved in mode changing.

18.4.4 CONSTRAINTS

18.4.4.1 General

The following are general constraints that apply to the SSU:

(a) The detector temperature must be maintained greater than $0^\circ C$ and less than $40^\circ C$ at all times.

(b) The baseplate temperature must be maintained greater than $0^\circ C$ and less than $30^\circ C$ at all times.

18.4.4.2 Launch and off Mode Operations

The following constraints are to be observed during all launch mode and off mode operations:

(a) The scan mirror is to be stowed in the blackbody look position.

(b) The SSU power must be off.

(c) The housekeeping telemetry should be on.

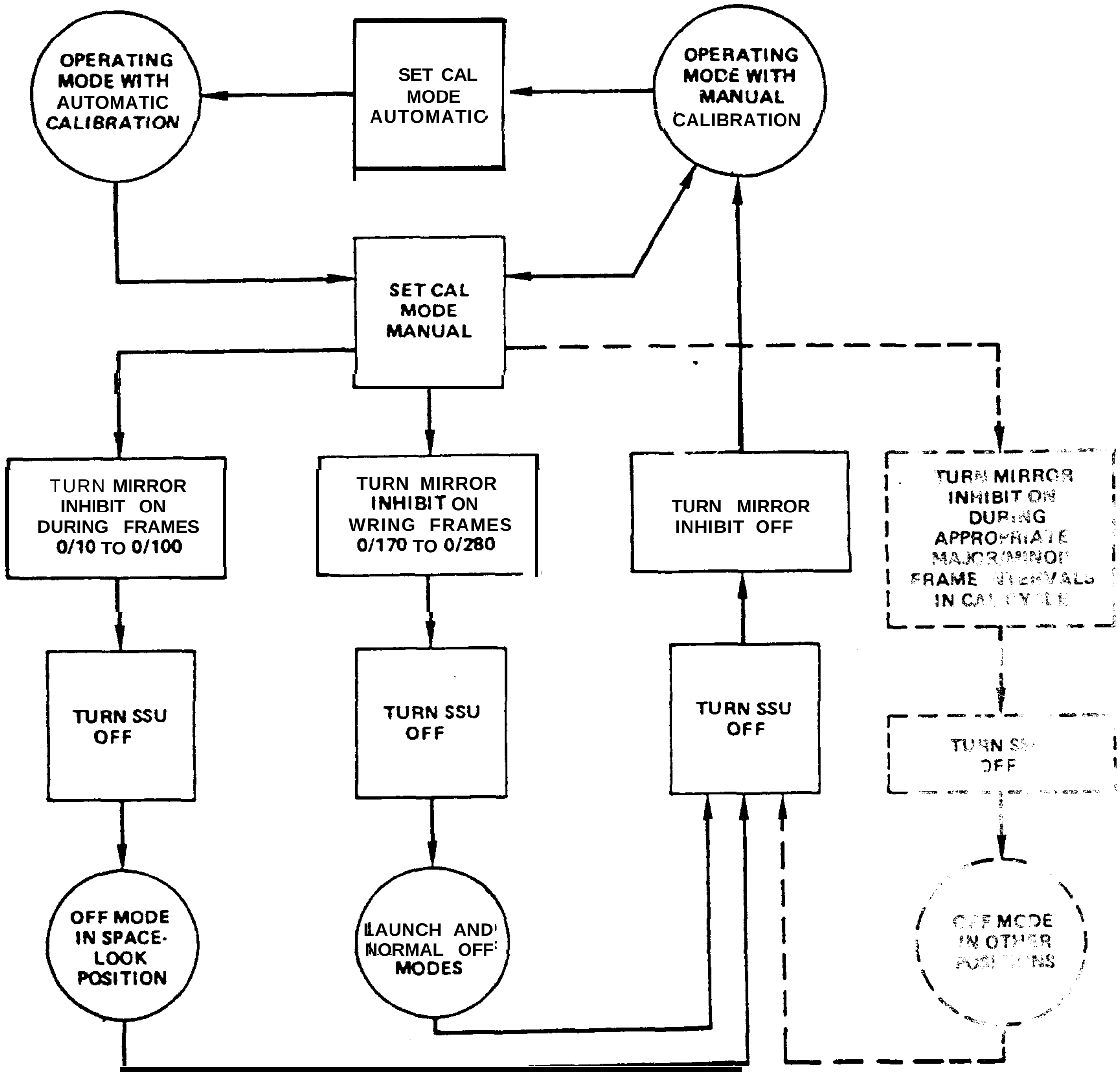


Figure 18.4-10. Representative SSU State Parameter Diagram

18.4.4.3 SSU Activation

During SSU activation and other turn-on operations, the scan mirror should be synchronized as described in paragraph 13.7.1.

18.4.4.4 Mission Operational and Inhibit Modes

When initiating the evaluation mission operational and inhibit modes, stabilize detector/PMC's at control temperature for:

(a) PMC control temperature = 30 $\pm 0.5^\circ C$.

(b) Detector control temperatures:

(1) PF1 = $25 \pm 0.5^\circ C$

(2) F2 - F8 = $30 \pm 0.5^\circ C$

18.5 SPACE ENVIRONMENT MONITOR (SEM)*

18.5.1 FUNCTIONAL DESCRIPTION

The Space Environment Monitor (SEM) is a multichannel charged-particle spectrometer which senses the flux of charged particles at the satellite altitude, and thus contributes to the solar-terrestrial energy knowledge. Within the past two decades, great strides have been made in defining the Sun's ionized plasma in which the Earth is immersed.

This solar wind is important because:

- Its pressure configures or contains the Earth's magnetic field (the magnetosphere)

  (a) It is a source of particles for the Earth's trapped radiation belts

  (b) It is the primary source of particles for particle precipitation phenomena (aurorea)

  (c) It is a major source of the energy input to the Earth's atmosphere and ionosphere

For these reasons alone, a charged-particle sensor to quantify these par-tide populations and dynamics is an important part of the mission. In addition, however, rather abrupt and large disruptive changes occur to the solar emissions which both dramatically change the instantaneous solar wind properties and also result in the arrival of an intense flux of high-energy (1 to over 1000 MeV) solar protons and alpha particles. Such events can result in dramatic changes to the magnetosphere geometry, large changes in energy inputs to the ionosphere and atmosphere disturbance or blackout of communications, excessive magnetic coupling to levels sufficient for burnout or circuit breaker trip of power and land-line communications systems, and even a radiation dosage threat to manned high-altitude flight.

For the reasons previously mentioned, NOAA has specified a SEM which will sense particles over a broad range of energies. The SEM is in reality two separate sensors with a common Data Processor Unit (DPU) as shown below:

(a) A Total Energy Detector (TED) which uses a programmed swept electrostatic curved-plate analyzer to select particle type/energy, and a channeltron detector to sense/quantify the intensity of the sequentially selected energy bands. The particles of interest range from 300 eV to 20 keV.

*The SEM is launched on alternating SK and is not scheduled for NOAA H.

(b) A Medium Energy Proton Electron Detector (MEPED) which senses protons, electrons, and ions with energies from 30 keV to several tens of MeV. This instrument utilizes solid-state nuclear detectors and appropriate arrangements of moderating materials to establish the energy band resolution.

18.5.2 SYSTEM DESCRIPTION

18.5.2.1 Introduction

Figure 18.5-l is a functional block diagram of the three sensors and their common Data Processor Unit (DPU). The location of those units on the ATN spacecraft is shown in Figure 18.5-2. A detailed description of each SEM unit is provided in the following paragraphs.

18.5.2.2 Total Energy Detector

18.5.2.2.1 Introduction-Figure 18.5-3 is the functional block diagram for TED. The TED consists of four curved-plate analyzers; two electron analyzers, one at 0 deg (the spacecraft-X axis, away from the Earth), and one at 30 deg to the -X axis, and a similar pair of positive-ion analyzers (0 deg and 30 deg) complete the set (see Figures 18.5-4 and 18.5-5 for diagrams). Each analyzer feeds a spiraltron (which is a member of the electronic multiplier family of devices called channeltrons), with two spiraltron High-W&age Power Supplies (HVPS) and a common deflection voltage ramp generator supply completing the front end. The two 0-deg spiraltron outputs are amplified and multiplexed into a common signal analyzer, as are the two 30-deg spiraltron outputs. TED data are fed to the DPU, where the required three parameters FD (Q), E_m, and $(DE)_m$ are computed for each of the four data species (E_0, E_{30}, P_0, and P_{30}). These 12 data sets are then multiplexed and fed to the ATN telemetry. For definitions of these parameters turn to para 18.5.2.5.

18.5.2.2.2 Performance Requirements-The TED performs the following functions:

(a) Measures the total directional energy flux of electrons and positive ions traveling from the anti-Earth direction and at 30 deg to this direction in the energy range of 0.300 to 20 keV.

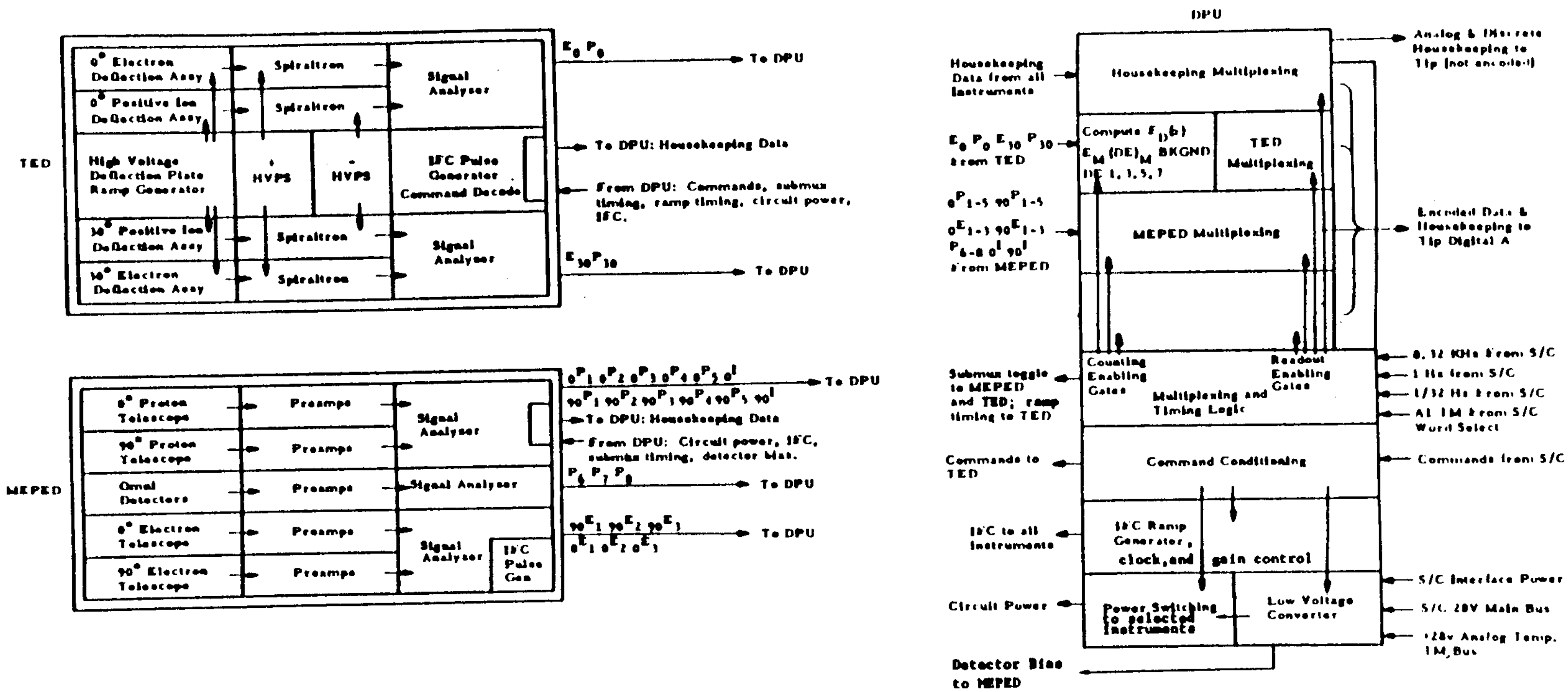
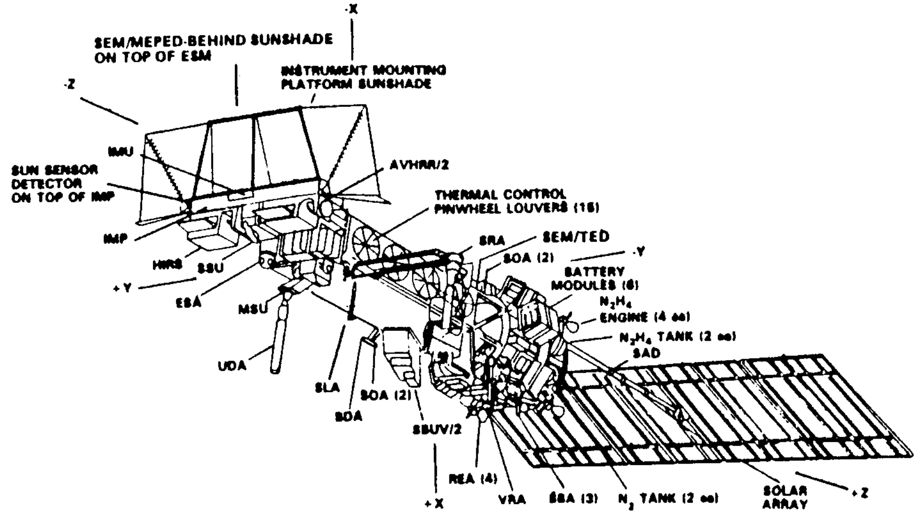
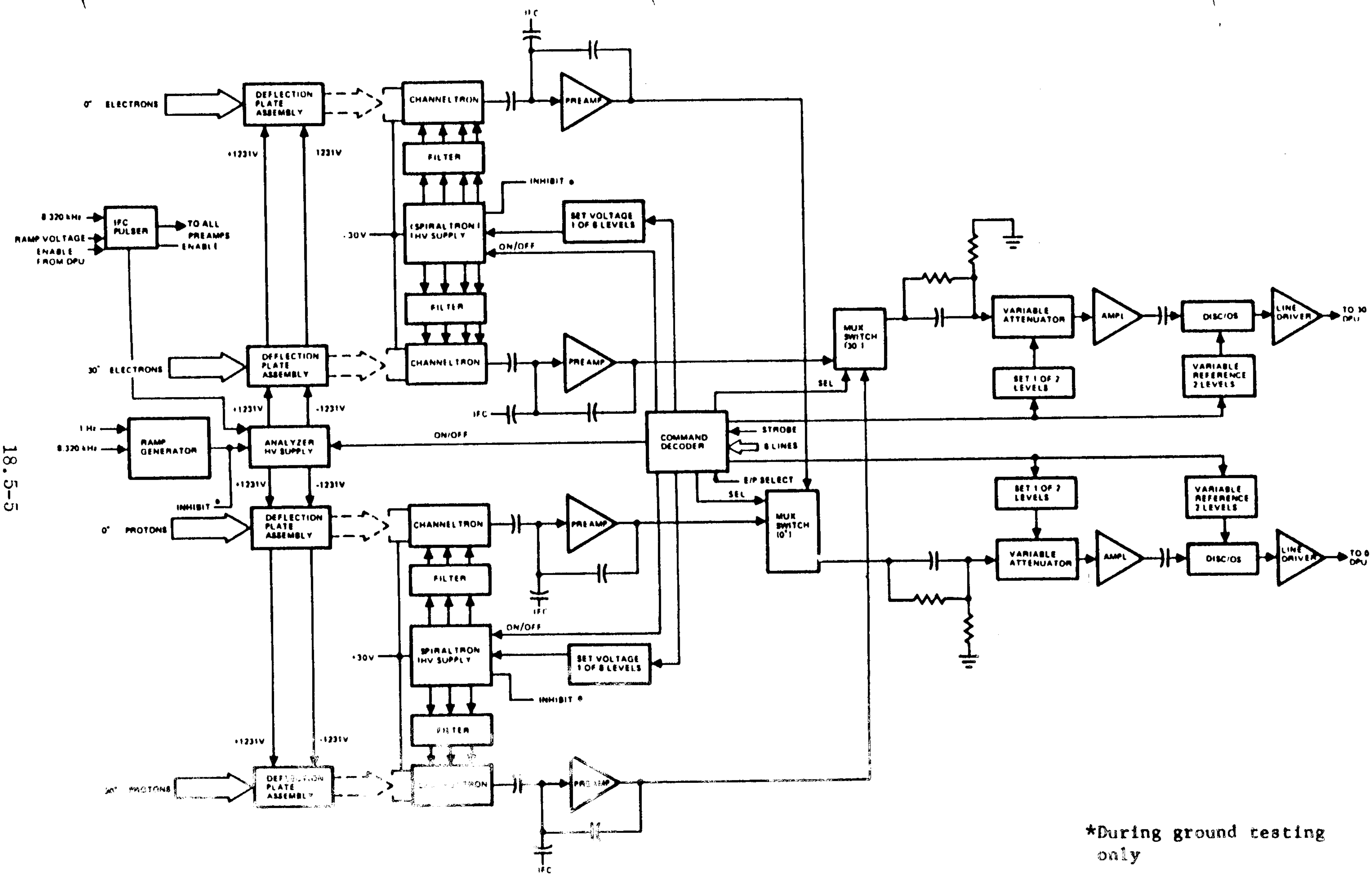


Figure 18.5-1. SEM Functional Diagram



LEGEND	
AVHRR/2	ADVANCED VERY HIGH RESOLUTION RADIOMETER
BDA	BEACON/COMMAND ANTENNA
ESA	EARTH SENSOR ASSEMBLY
HIRS/2I	HIGH-RESOLUTION INFRARED SOUNDER
IMP	INSTRUMENT MOUNTING PLATFORM
IMU	INERTIAL MEASUREMENT UNIT
MSU	MICROWAVE SOUNDING UNIT
REA	REACTION ENGINE ASSEMBLY
SAD	SOLAR-ARRAY DRIVE
SBA	S-BAND ANTENNA
SBUV/2	SOLAR BACKSCATTER ULTRAVIOLET SPECTRAL RADIOMETER
SLA	SEARCH-AND-RESCUE TRANSMITTING ANTENNA (L-BAND)
SOA	S-BAND OMNI ANTENNA
SRA	SEARCH-AND-RESCUE RECEIVING ANTENNA
SSD	SUN SENSOR DETECTOR
SSU	STRATOSPHERIC SOUNDING UNIT
UDA	ULTRA-HIGH-FREQUENCY DATA COLLECTION SYSTEM ANTENNA
VRA	VERY-HIGH-FREQUENCY REAL-TIME ANTENNA
SEM/MEPED	SPACE ENVIRONMENT MONITOR/MEDIUM ENERGY PROTON & ELECTRON DETECTOR
SEM/TED	SPACE ENVIRONMENT MONITOR/ TOTAL ENERGY DETECTOR

Figure 18.5-2. SEM Unit Locations on ATN



*During ground testing only

Figure 18.5-3. TED Functional Block Diagram

(b) Performs a measurement for each particle species at each angle. It measures the total energy transported by particles in the energy range, the energy interval in which the maximum differential flux occurs, and the value of the maximum flux. In addition, a background measurement is performed and subset of the differential energy fluxes measured.

(c) Transmits to the DPU random digital pulse trains on four data lines representing positive ions and electrons at each of the two angles.

(d) Provides an in-flight calibration capability and housekeeping readouts, to the DPU, which allow real-time verification of performance or correction of performance parameters.

(e) Provides the capability of responding to ground command to maintain performance by compensating for aging effects.

Table 18.5-l summarizes these requirements with corresponding resolution and accuracy ranges.

18.5.2.2.3 TED In-Flight Calibration-The TED In-Flight Calibration (IFC) is performed in two parts:

(a) During four 192-sec periods, pulse ramps of known form are injected into the analog electronics; the electrostatic analyzer plates are disabled; and the level discriminators cycled, spending one period at each level.

(b) For the next 102.4 min, corresponding to approximately one orbit, the calibration pulses are turned off, the deflection plates operated normally, and the cycling of the level discriminators continued but with a 2-sec period. Provisions for an override command from the ground for the termination of the IFC will be provided by the DPU.

The purpose of the initial four 192-sec periods is to provide signals of known form into the analog system for level discriminator settings and for the electronics operation to be verified. The second longer period allows ambient particle flux to be used as an aid in measuring the gain and pulse height distribution of the spiraltron to determine if the spiraltron high voltage should be changed.

18.5.2.2.3.1 TED Calibrating Signals-The TED has one calibrating input and receives calibrating signals in four 192-sec periods.

TABLE 18.5-1. TED PERFORMANCE REQUIREMENTS

Sensor Assemblies	Energy Band	Directionality	Energy Flux Value
Positive Ions	300-20 keV	0^{0} & 30^{0}	10^{-2} to 32 ergs/cm^{2}-sec-ster
Electrons	300-20 keV	0^{0} & 30^{0}	10^{-2} to 100 ergs/cm^{2}-sec-ster

Measurements Performed: (Each Sensor Assembly)	Resolution	Absolute Accuracy
Total Directional Energy Flux, F_D (α)	15% for $F_D(\alpha)$ <6×10^{-2}ergs/cm^{2}-ster-sec 5% for $F_D(\alpha)$ >6×10^{-2}ergs/cm^{2}-ster-sec	$\pm$50%
Maximum Differential Flux, $(DE)_m$	15% for $(DE)_m$ <3×10^{-3}ergs/cm^{2}-sec-ster-keV 5% for $(DE)_m$ >3×10^{-3}ergs/cm^{2}-sec-ster-keV	$\pm$50%
Energy at Which $(DE)_m$ Occurs, E_m		$\pm$30%

18.5.2.2.3.2 TED Level Discriminator Modulation-While calibrating signals are being presented, the DPU will simultaneously cycle the four LD's through each of their four levels, spending a 192-sec period at each of the four levels and then cycling to the next level. The beginning of each 192-sec period will be used by the DPU to command the level sensors to their next level. The commands will be delivered sequentially to the four discriminators involved. Level change will become effective in less than 1 msec.

18.5.2.2.3.3 Data Telemetry Mode-During this time interval, telemetry data will be presented in mode 1, presenting data from all four sensors for telemetry to ground. The last 153 msec of the TED 2-sec minor frame will be used by the DPU to command the level sensors to their next level. A change in level will occur every 2 sec. On ground command, or at the end of 102.4 min, level sensor cycling will halt and the TED will return to normal data mode.

18.5.2.2.3.4 TED IFC Details-Table 18.5-2 indicates the required measurements for the channels during IFC. For definition of channel indicatora, see para 18.5.2.5.

TABLE 18.5-2. TED IFC DETAILS

Channels for Descriminator Thresholds			
$0^{EF}D$	$0^{PF}D$	$30^{EF}D$	$30^{PF}D$
Channels for Limit Check			
$0^{DE}1$	$0^{DE}3$	ODE5	ODE7
$30^{DE}1$	$30^{DE}3$	$30^{DE}5$	$30^{DE}7$
$0^{DP}1$	$0^{DP}3$	$0^{DP}5$	$0^{DP}7$
$30^{DP}1$	$30^{DP}3$	$30^{DP}5$	$30^{DP}7$
$0^{E}m$	$30^{E}m$	$0^{P}m$	$30^{P}m$
$0^{DE}m$	$0^{DP}m$	$30^{DE}m$	$30^{DP}m$
Channels for Background Check			
$0^{EF}D$	$0^{PF}D$	$30^{EF}D$	$30^{PF}D$

18.5.2.3 Medium Energy Proton Electron Detector

18.5.2.3.1 Introduction-The MEPED is a collection of four directional solid-state detector telescopes and one omnidirectional sensor. All five MEPED sensors utilize solid-state silicon nuclear detectors The telescopes are of two types, a two-detector proton telescope and a one-detector electron telescope. One set of electron and proton telescopes is oriented along the satellite -X or anti-Earth axis (the O-deg telescopes), and the other pair is at 90 deg to the -X axis. The amount, type, and position of the telescope moderating materials and the telescope detectors produce a correspondence of the quantity of charge generated by an incident charged particle to the type and energy of that particle. Each solid-state detector is connected to its own low-noise charge-sensitive preamplifier. The proton telescope preamps are multiplexed to a common proton signal analyzer while the electron telescopes are multiplexed to a separate electron signal analyzer. Each signal analyzer consists of a group of pulse amplifiers, level discriminators, and logic that sort each event into the appropriate bin characteristic of the particle type and energy. The outputs of each bin are pulses of fixed amplitude occurring irregularly in time but in virtual coincidence with the primary particle event, which are fed to the DPU where they are accumulated, multiplexed, and fed to the spacecraft telemetry.

The omni-detector is a set of three lithium-drifted solid-state detectors mounted under spherical shell caps of carefully specified and controlled nuclear stopping power. The effective field-of-view of each detector is approximately half of a hemisphere. Like the telescopes, these units are connected, via charge-sensitive preamps, to a signal analyzer which senses and logically selects those events which exceed a specific threshold. These (P6 and P8) data are fed to the DPU to be processed in the same manner as the telescope data. The MEPED telescope designs are similar to sensor flown by NOAA on ITOS and by NASA on SMS and Apollo, except that they incorporate significant improvements in low-noise technology, allowing the detection of very low energy particles with good resolution. The MEPED omni-sensor is the modified dome assembly qualified on the GOES-B and -C program. Figure 18.5-4 is the MEPED functional block diagram.

On NOAA H and subsequent satellites, the maximum gamma angle was changed from 68 to 80 degrees. This change caused the IMP sunshade to be enlarged which would have violated the MEPED FOV. A deployment mechanism was developed for the MEPED to correct this problem.

18.5.2.3.2 Performance Requirements-The MEPED performs the following functions:

(a) Measures the directional proton and electron flux incidental to both the spacecraft -X and -Z axes. Measures the omnidirectional proton flux within a conical field of view, half angle 60 deg, whose axis is along the spacecraft -X direction.

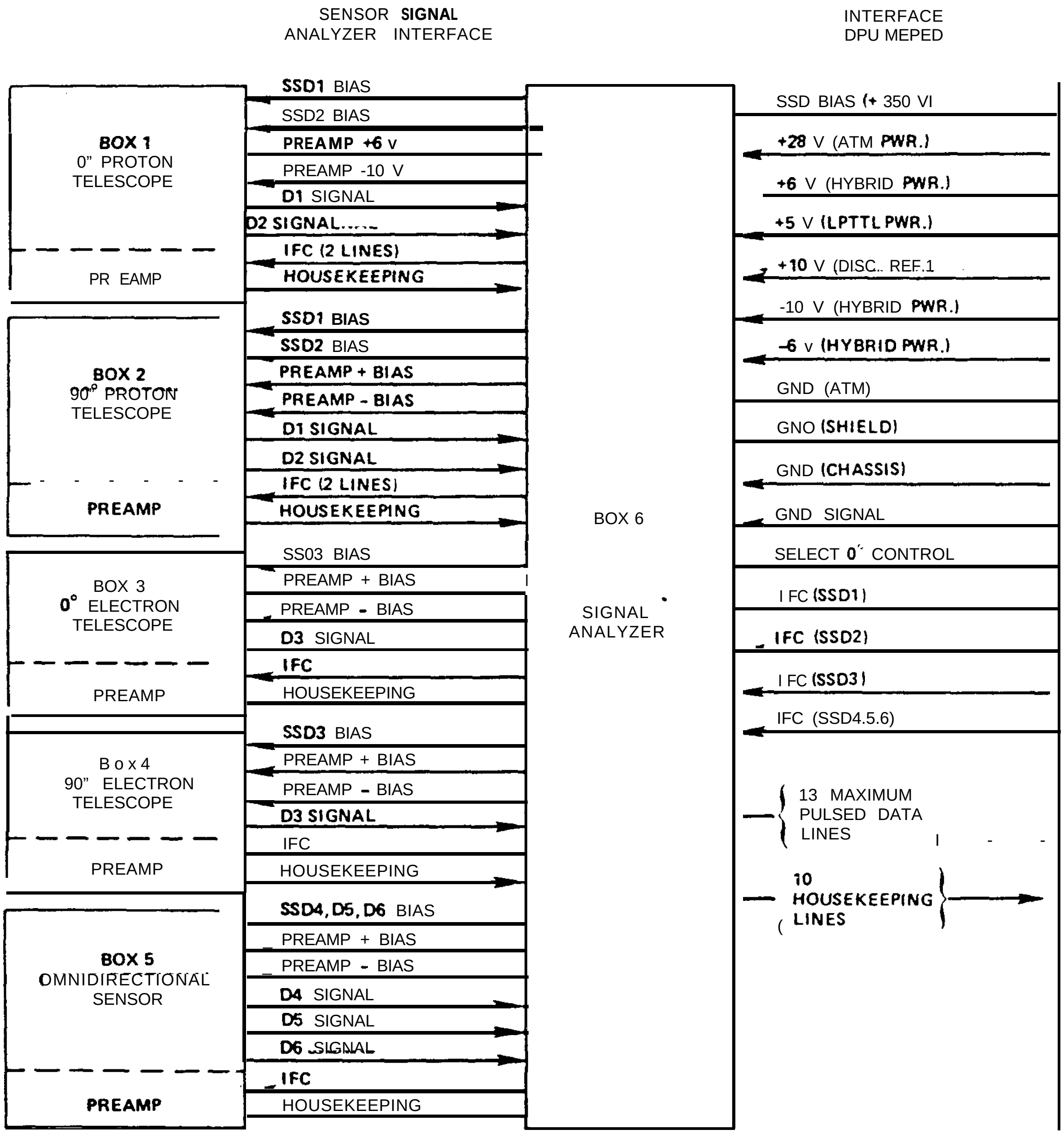


Figure 18.5-4 MEPED Functional Block Diagram

(b) Transmits to the DPU digital pulses representing the counting rate of each instrument in the above spectral intervals.

(c) Provides in-flight calibration capability and housekeeping functions which define the resolution of the instrument.

Table 18.5-3 summarized these requirements with corresponding energy ranges and resolution/noise range.

18.5.2.3.3 In-flight Calibration-The MEPED IFC consists of three phases of 192 sec each. The various ramp amplitudes are specified in Table 18.5-J. There are two types of parameters determined during the IFC, thresholds for 15 level sensors and full-width half maximum's for nine solid-state detectors,

TABLE 18.5-3. MEPED PERFORMANCE REQUIREMENTS

A. Telescope Assemblies[3]		Nominal Energy Band	Directionality	Field of View	Resolution/ Noise (FWHM)
1. Protons	P1	30[1] - 80 keV	0° & 90°	$\leq 30^\circ$	$\leq$7 keV
	P2	80 - 250 keV	"	"	"
	P3	250 - 800 keV	"	"	"
	P4	800 - 250 keV	"	"	$\leq$2%[2]
	P5	$\geq$2500 keV	"	"	"
2. Electrons	E1	$\geq$30[1] keV	"	"	$\leq$7 keV
	E2	$\geq$100 keV	"	"	"
	E3	$\geq$300 keV	"	"	"
3. Ions	I	$\geq$6000 keV	"	"	$\leq$2%
B. Omni Sensor	P6	$\geq$10 MeV	no	~ π Steradian	$\leq$60 keV
	P7	$\geq$30 MeV	"	"	"
	P8	$\geq$60 MeV	"	"	"

Notes:

1 Required thresholds; other values nominal to within $\pm$20%.

2 Determined by Level Sensor Stability.

3 Both proton and electron telescopes are capable of measuring a maximum flux of 5×10^7 particles/cm^2-sr exceeding in amplitude the lowest energy threshold. The response of the proton and electron telescopes saturate at this value. When driven at rates up to 5×10^9 particles/cm^2-sr-sec, the output response of the instrument must not be double valued for an equivalent response less than 4×10^7 particles/cm^2-sr-sec.

TABLE 18.5-4. MEPED IFC PARAMETERS

Detector	Amplitude	Phase	Energy
D_1 D_2 D_3	0-3.4 mV	1	0-75 KeV
D_1 D_3	0-144 mV	2	0-3.2 MeV
D_1	0-450 mV		0-10 MeV
D_2	0-1.35 V	3	0-31 MeV
D_3	0-144 mV		0-3.2 MeV
D_{4-6}	0-54 mV	1-3	0-1.2 MeV

FWHM for 9 Detectors (Phase 1 Only)						
$0^{P}1$	$90^{P}1$	$0^{E}1$	$90^{E}1$	P_6	P_7	P_8

Threshold Check 15 Level Sensors (Three Phases)		
Phase I	Level Sensors	Data Channel
Proton	1,7	P_1
Electron	1	E_1
Omni	1-3	P_6, P_7, P_8
Phase II	Level Sensors	Data Channel
Proton	2-5	P_2, P_3, P_4
Electron	1-4	E_{1-3}
Omni	1-3	P_6, P_7, P_8
Phase III	Level Sensors	Data Channel
Proton	3,8	P_5
Ion	6	I
Electron	1-4	E_{1-3}
Omni	1-3	P_6, P_7, P_8

Note: During periods with no IFC, all channels will be limit checked for background.

18.5.2.4 Data Processor Unit

18.5.2.4.1 Introduction-The SEM DPU consists of the following functional elements:

(a) Timing and Control

(b) Analog and Digital Multiplexer

(c) Particle Detector Data Processors

(d) A/D Converter

(e) Formatter

(f) Command Processor

(g) Ramp Generator and Calibration Programmer

Figure 18.5-5 is the DPU functional block diagram. Each element will be discussed in the following paragraphs.

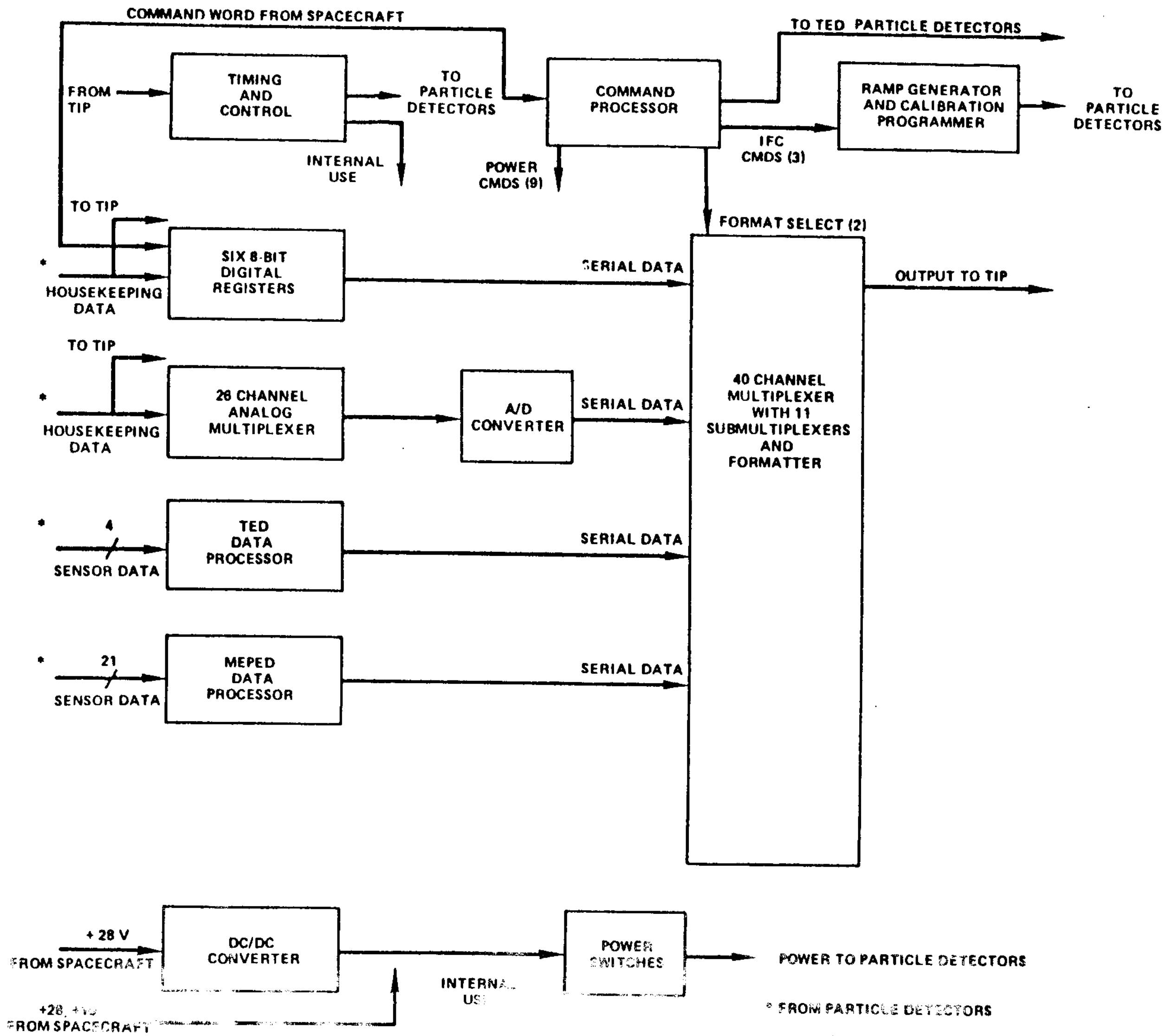


Figure 18.5-5 DPU Block Diagram

18.5.2.4.1.1 Timing and Control-The timing and control receives signals from the spacecraft and uses these signals to generate all the timing signals necessary within the DPU and the three particle detectors. The following timing signals are received by the DPU:

(a) 1/32 sec sync (32 sec is a major-data frame period)

(b) 1 sec sync

(c) 8.32 kHz

(d) Al Select

Signals (a) and (b) are used to synchronize with the TIP minor frame and major frame. Signal (c) is used as the basic clock in all the circuits and is also the rate at which data are being transmitted to TIP. Signal (d) determines the time in a TIP minor frame of 100 msec when data from DPU are being transmitted. This signal is received only when TIP wants DPU data.

18.5.2.4.1.2 Analog and Digital Multiplexer-In addition to processing of data from the sensors, the DPU receives analog and digital housekeeping data from the particle detectors. The DPU handles these data in two ways:

(a) The DPU has 26 analog and 48 digital channels available at sampling rate of once in 32 sec. It converts each analog word into 8 bits and inserts the converted data together with the digital data into Digital A Output to the TIP.

(b) Some of the housekeeping data are being transmitted directly to the spacecraft, each source is on a separate line.

18.5.2.4.1.3 Particle Detector – Data Processor-Data received from the particle detectors constitute a series of random pulses. The average rates are measured in a special compression counter, the 623C. This counter converts on command a 19-bit binary number into an exponent Y and mantissa X, X and Y having four bits each. The 8-bit number of each source has a time slot assigned to it in the Frame Format (refer to Table 18.5-5). The MEPED data are treated in this way.

The data from TED are processed in the following special way (all measurements are made over a 1-set period):

TABLE 18.5-5. SEM OUTPUT FORMAT

Subframe	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		[illegible]	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	0 01	DF1	1 DF2	DF3	2 DF4	DF5	3 DF1	DF2	4 DF3	P1	5 (1)	P2	6	P3	7	P4	8	M1	9 M2		10	10F1	11 10F2	10F3	12 10F4	10F5	13 [illegible]	[illegible]	14 [illegible]	[illegible]	15 [illegible]	[illegible]	16		17		18		19	
2	20 VO1									S3		S4		S1		S2		S3	29 An																					
3	40 An									P1		P2		P3		P4		M1	49 M2																					
4	60 An(2)									S3		S4		S1		S2		S3	69 An																					
5	80 An									P1		P2		P3		P4		M1	89 M2																					
6	100 An									S3		S4		S1		S2		S3	109 An																					
7	120 An									P1		P2		P3		P4		M1	129 M1																					
8	140 An									S3		S4		S1		S2		S3	149 An																					
9	160 D1									P1		P2		P3		P4		M1	169 M2																					
10	180 VD1									S3		S4		S1		S2		S3	189 An																					
11	200 An									P1		P2		P3		P4		M1	209 M2																					
12	220 An									S3		S4		S1		S2		S3	229 An																					
13	240 An									P1		P2		P3		P4		M1	249 M2																					
14	260 An									S3	265 Dig.(1)	S4	266 Dig.	S1	267 An	S2	268 An	S3	269 An																					
15	280 An									P1	285 Dig.	P2	286 Dig.	P3	287 An	P5	288 An	M1	289 M1																					
16	300 An									S3	305 Dig.	S5	306 Dig.	S1	307 An	S2	308 An	S3	309 An																					

Note:

2 ← DPU Word Assignment 1 through 19.

A B ← 8-Bit Word Designation. Two per minor frame.

XXX ← Spacecraft minor frame 0 through 319.

002 | 094 ← SEM Data Assignment.

Note:

(1) Data assignment of blank boxes depends upon TED/DPU Mode selection.

*(2) An = Analog word assignment.

*(3) Dig = Digital word assignment.

* See next pages for assignments.

Note:

Spacecraft minor telemetry frames are numbered 0 through 319 in the major frame. Each minor frame includes two eight bit SEM words. The DPU format has divided the spacecraft major frame into 16 subframes with 20 words per subframe. Spacecraft minor frame 120A (assigned to an analog house-keeping word) would be referred to as word 1 A/7 in the DPU format.

Telemetry Format

TABLE 18.5-5a. SEM OUTPUT FORMAT (Cont.)

Digital Subcom Words

	Frame 265 Word A	Frame 266 Word A	Frame 285 Word A	Frame 286 Word A
(MSB) 1	TED(E_0 - P_0)PHD bit 0	Level Command 0, (DCB 1)	TED IFC on/off	Pulse Command PC 1
2	TED(E_0 - P_0)PHD bit 1	Level Command 1, (DCB 2)	MEPED IFC on/off	Pulse Command PC 2
3	TED(E_{30} - P_{30}) PHD bit 0	Level Command 2, (DCB 3)	Low Voltage Converter on/off	Pulse Command PC 3
4	TED(E_{30} - P_{30}) PHD bit 1	Level Command 3, (DCB 4)	Spare	Pulse Command PC 4
5	TED Mode Status bit 0	Level Command 4, (DCB 5)	Spare	Telemetry Mode 1/2
6	TED Mode Status bit 1	Level Command 5, (DCB 6)	Spare	Spare
7	TED On/Off	Level Command 6,(DCB 7)	Spare	Spare
(LSB) 8	MEPED On/Off	Level Command 7, (DCB 8)	Spare	Spare

Note:

Frame 305 Word A = Synch Pattern (1111 0011)
Frame 306 Word A = Synch Pattern (01010000)
For major frame sync if S/C sync is lost.

TABLE 18.5-5b. SEM OUTPUT FORMAT (Cont.)

Analog Housekeeping Subcom

Minor Frame	Word	Nomenclature
29	A	MEPED SSD Bias Monitor (Electron)
40	A	MEPED SSD Bias Monitor (Proton]
60	A	MEPED Omni Temperature
69	A	Spare
80	A	MEPED Electronic Temperature
100	A	MEPED Proton Telescope Temperature
109	A	Spare
120	A	MEPED Electron Telescope Temperature
140	A	DPU Temperature Sensor
149	A	Spare
189	A	Spare
200	A	Spare
229	A	TED E Channeltron PS Monitor
240	A	Spare
260	A	TED P Channeltron PS Monitor
267	A	DPU + 12V Monitor
268	A	TED Low Voltage Ramp Monitor
269	A	Spare
280	A	Spare
287	A	Spare
288	A	TED CEAPS Monitor
300	A	Spare
307	A	Spare
308	A	DPU IFC Ramp
309	A	Spare

(a) Background Measurement. Background measurement (particle count) is made over the first 78 msec of the 1-sec period when the ramp applied to the channeltron is at its lowest value.

(b) Total Flux Measurement. Total flux measurement begins when the background measurement ends, and lasts for 11/13 of the 1-sec period. For this measurement, a 5-bit prescaler is used ahead of the 623C counter. The data rate reaching the counter is enhanced as the ramp voltage increases. A special procedure is followed when the count is small (≤16).

(c) Differential Flux Measurement. For this measurement the 1-see period is split into 13 equal intervals. Counts during periods 2, 4, 6, and 8 are transmitted for each of the four TED sensors. In addition, the maximum count during one period and the index of the period in which it occurred is determined.

18.5.2.4.1.4 Data Formatter-The data from particle detectors and the house-keeping data are formatted into a 320-word frame as listed in Table 18.5-5. The major frame contains 16 minor frames. A minor frame contains 20 double words (16 bits). The data rate to the TIP is 160 bps and is sent only when an Al-select signal is received.

18.5.2.4.1.5 Command Processor-The DPU receives 12 command lines from the spacecraft. Eight of these are level command; 0 V for a logic one and 10 V for a logic 0. The four remaining are pulse commands. The DPU decodes these inputs and performs the following functions:

(a) Switches the Power ON/OFF to each of two particle detectors.

(b) Establishes Mode 1 or Mode 2 of data transmission.

(c) Starts calibration of Particle Detectors.

(d) Terminates Calibration.

(e) Switches ON/OFF power to the dc-dc converter of DPU.

18.5.2.4.1.6 Ramp Generator and Calibration Programmer-In response to a received command, the DPU generates a linear ramp and corresponding timing signals necessary to perform the calibration of each particle detector. The calibration sequence is self-terminating and may also be terminated on command.

18.5.2.4.2 Performance Requirements-The SEM DPU performs the following functions:

(a) Accumulate pulse outputs from the TED and MEPED particle detectors and provide count rate data.

(b) Sample analog and digital housekeeping data from the particle detectors and digitize the analog date to 8 bits.

(c) Format the above data into a serial telemetry data stream to the TIROS Information Processor (TIP).

(d) Provide analog and digital data from particle detectors and DPU directly to the TIP.

(e) Receive, decode, and execute applicable commands.

(f) Provide a linear ramp and timing signals for the particle detector in-flight calibrators.

(g) Provide secondary power to the particle detectors from a dc-dc converter.

18.5.2.5 SEM Data

18.5.2.5.1 Introduction-The output data signals supplied by the instrument to the spacecraft fall into the following three categories:

(a) Digital-A Data.

(b) Digital-B Telemetry.

(c) Analog Telemetry.

The specific signals supplied by the SEM are detailed in the following paragraphs.

18.5.2.5.2 Digital-A Data-Digital-A data are clocked into the spacecraft TIP whenever the "A_1" Data Enable Pulse is presented to the instrument. Details of the digital-A timing and interface characteristics are presented in para 3.1.8 of the General Instrument Interface Specification doument (RCA #IS2280259). The instrument data are as follows :

(a) Content-The data are categorized by type (ions, protons, electrons) energy level, instrument (MEPED, TED), and detector pointing direction within SEM. All data are output in the format as listed in Table 18.5-5. The format repeats every major frame (32 sec).

(b) Data Coding-The shorthand notation used to refer to the various data channels in the SEM telemetry format the symbols P, 0, and I are used, where:

(1) P = Particle symbol.

(2) 0 = Axis of field of View (0 deg, 30 deg or 90 deg).

(3) I = Channel number identifier.

Refer to Table 18.5-6.

(c) SEM Output Format-The SEM data will be transmitted to TIP in the format as listed in Table 18.5-5. .

(d) Data Conversion—The DPU uses the SMI Type 623 Floating Point Processor to perform particle flux measurement. The Type 623 is intended to provide pulse counting, conversion of the binary count to floating point (logarithmic compression), temporary storage of a compressed number while simultaneously counting a second value, and serial readout. The processor receives a number of pulses in a predetermined time interval up to 491521 (19 bits) and compresses the received number into 8 bits. The 8 bits resulting from the compression are located in a shift register ready to be shifted out.

The first four bits of the 8-bit word designated as Y constitute an exponent and the last four designated as X a mantissa. The conversion transfer function listing Y and X versus the number of input pulses is described in the equations below. The SEM output word will be in an eight bit word format with bit 0 the LSB and bit 7 the MSB. This output word represents a log function which can be converted to counts by the equation:

$$\text{counts} = \left[(X + 16) \times 2^{(y + 6)}\right] + 1$$

where bits 7, 6, 5 and 4 represent the y exponent and bits 3, 2, 1, and 0 the x mantissa. The exceptions to this relationship are:

- if y = 8 and x = 15, the total counts will be zero.

TABLE 18.5-6. DATA CODING

Particle Symbol		
Symbol	Type	Function/Source
I	LOG	Ions/MEPED
P	LOG	Protons/MEPED
P	LOG	Positive Ions/TED
E	LOG	Electrons/MEPED, TED
DE	LOG	Diff. Energy, Electrons/TED
DP	LOG	Diff. Energy, Protons/TED
EF	LOW Prescaled	Total Directional Flux, Electrons/TED
PF	LOW Prescaled	Total Directional Flux, Protons/TED
AN	Integer	Analog/Subcom'ed
DIG	Status Bits	Digital/Subcom'ed

Channel Number Identifier	Channel Number
1-8	
m	With P or E. Indicates an integer number identifying the DE channel in which max counts appeared.
m	With DE or DP. Indicates a log output of the total counts in the channel under question.
0	Part of the EF, PF total Directional Flux identifier.
BK	Background

- if y = 9, the total counts will be x + 1.
- if y = 10 to 15, the total counts will be determined by the equation:

$$\text{counts} = \left[(x + 16) \quad 2^{(y - 10)}\right] + 1$$

The conversion transfer function listing Y and X versus counts is listed in Table 18.5-7.).

18.5.2.5.3 Digital-B Telemetry

18.5.2.5.3.1 General. The digital-B one-bit status telemetry shall be available at the instrument interface at all times. The 3.2-sec subcom telemetry generated by the TIP will sample each digital-B point once every 3.2 sec. Word 8 of the minor frame will be dedicated to the sampling of digital-B telemetry from all spacecraft components.

18.5.2.5.3.2 Digital-B Telemetry Points. The digital-B telemetry points provided by the SEM are listed in Table 18.5-8. All of the SEM digital-B telemetry points are included in the SEM digital-A data.

18.5.2.5.4 Analog Telemetry

18.5.2.5.4.1 General-The analog telemetry shall be available at the instrument interface at all times. Three different subcoms (32, 16, and 1-see) generated by the TIP will be used to sample all spacecraft analog telemetry.

18.5.2.5.4.2 Analog Telemetry Points-The analog telemetry points provided by the SEM are listed in Table 18.5-9. All of the SEM analog telemetry points are included in the SEM digital-A data.

18.5.3 MODES OF OPERATION

18.5.3.1 Prelaunch and Launch

The SEM will be checked out during launch pad GO/NO GO testing. The SEM will be verified in the OFF condition for launch.

18.5.3.2 Depressurization Mode

This mode is required to allow the escape of pressure from the electron telescopes. A minimum of 10 days will be required in this mode. The SEM will be verified in the OFF condition for this mode.

TABLE 18.5-7. 623 FLOATING POINT PROCESSOR 19-8 ALGORITHM

Y X=	0	1	2	3	4	5	6	7
0	1025	1089	1153	1217	1281	1345	1409	1473
1	2049	2177	2305	2433	2561	2689	2817	2945
2	4097	4353	4609	4865	5121	5377	5633	5889
3	8193	8705	9217	9729	10241	10753	11265	11777
4	16385	17409	18433	19457	20481	21505	22529	23553
5	32769	34817	36865	38913	40961	43009	45057	47105
6	65537	69633	73729	77825	81921	86017	90113	94209
7	131073	139265	147457	155649	163841	172033	180225	188417
8	262145	278529	294913	311297	327681	344065	360449	376833
9	1	2	3	4	5	6	7	8
10	17	18	19	20	21	22	23	24
11	33	35	37	39	41	43	45	47
12	65	69	73	77	81	85	89	93
13	129	137	145	153	161	169	177	185
14	257	273	289	305	321	337	353	369
15	513	545	577	609	641	673	705	737

Y X=	8	9	10	11	12	13	14	15
0	1537	1601	1665	1729	1793	1857	1921	1985
1	3073	3201	3329	3457	3585	3713	3841	3969
2	6145	6401	6657	6913	7169	7425	7681	7937
3	12289	12801	13313	13825	14337	14849	15361	15873
4	24577	25601	26625	27649	28673	29697	30721	31745
5	49153	51201	53249	55297	57345	59393	61441	63489
6	98305	102401	106497	110593	114689	118785	122881	126977
7	196609	204801	212993	221185	229377	237569	245761	258953
8	393217	409601	425985	442369	458753	475137	491521	0
9	9	10	11	12	13	14	15	16
10	25	26	27	28	29	30	31	32
11	49	51	53	55	57	59	61	63
12	97	101	105	109	113	117	121	125
13	193	201	209	217	225	233	241	249
14	385	401	417	433	449	465	481	497
15	769	801	833	865	897	929	961	993

TABLE 18.5-8. SEM DIGITAL-B TELEMETRY

No.	Telemetry Point Name	State *		Minor Frame	Ch. #	Word 8 Bit #
		Logic 1	Logic 0			
1	LV Converter On/Off	ON	OFF	25	185	6
2	TED Power On/Off	ON	OFF	25	217	7
3	Spare	ON	OFF	25	249	8
4	MEPED Power On/Off	ON	OFF	26	26	1
5	TED IFC IN Process Yes/No	YES	NO	26	58	2
6	MEPED IFC IN Process Yes/No	YES	NO	26	90	3
7	L.D. Cmd. LC0 (DCB-1)	1	0	26	122	4
8	L.D. Cmd. LC1 (DCB-2)	1	0	26	154	5
9	L.D. Cmd. LC2 (DCB-3)	1	0	26	186	6
10	L.D. Cmd. LC3 (DCB-4)	1	0	26	218	7
11	L.D. Cmd. LC4 (DCB-5)	1	0	26	250	8
12	L.D. Cmd. LC5 (DCB-6)	1	0	27	27	1
13	L.D. Cmd. LC6 (DCB-7)	1	0	27	59	2
14	L.D. Cmd. LC7 (DCB-8)	1	0	27	91	3
15	Telemetry Format 1/2	1	2	27	123	4

* Logic 1 is a True or Low Voltage state.

TABLE 18.5-9. SEM ANALOG TELEMETRY

No.	Telemtry Point Name	Sub Com (1) Sec	Minor Frame	Ch #
1	TED Temperature *	32	214	214
2	TED CEA PS Monitor	32	222	222
3	TED Channeltron E Bias Voltage	32	119,279	119
4	TED Channeltron P Bias Voltage	32	127,287	127
5	MEPED Proton Telescope Temperature*	32	135,295	135
6	MEPED Electron Telescope Temperature*	32	230	230
7	MEPED Detector Bias Voltage	32	143,303	143
8	Spare	32	151,311	151
9	Spare	32	159,319	159
10	Spare	16	111,271	286
11	Spare	16	4,164	294
12	IFC Ramp	16	96,256	302
13	DPU Temperature Monitor*	16	97,257	310
14	MEPED Electronics Temperature	16	3,163	318
15	TED LV Ramp	16	2,162	326

Notes:

1. The 32, 16 and 1- sec Analog Subcom data are read out in words 9, 10, and 11 respectively, of each TIP minor frame.

* Indicates points on the 28V Analog Telemetry Bus.

18.5.3.3 Activation Mode

After completion of depressurization, the SEM will be turned ON. Each instrument will be turned ON sequentially and correct bias voltages will be established. Each instrument will be commanded into the calibration mode.

18.5.3.4 Calibration Mode

This mode is required for checking level sensor thresholds in TED and MEPED. The in-flight calibration system is used as a means of measuring the performance of the electronic channels.

18.5.3.5 Mission Mode

After the SEM has been activated and the results evaluated, it will be placed in the Mission Mode for turnover to NOAA. Periodic return to the calibration mode will be required.

18.5.3.6 SEM Off Mode

The TED and MEPED can be commanded off separately in case of difficulties with the instrument, or to conserve spacecraft power. The decision for turning off will he made by the METSAT project office.

18.5.4 CONSTRAINTS

18.5.4.1 Introduction

The various modes of operation have specific requirements (constraints) that must be complied with prior to initiation of a mode. In addition, once a mode has been established, additional constraints must be met in order to maintain a safe condition. Terminating a mode establishes additional constraints. The following discussions of constraints during the various modes are based primarily on the requirements as currently defined by the SEM specifications.

18.5.4.2 Prelaunch and Launch

The prelaunch and launch constraints are as follows:

(a) During prelaunch testing, the test connectors' dummy plugs must be installed. These test connectors are not used for launch pad testing.

(b) Prior to spacecraft closeout, TED and MEPED sensor dust covers must be removed and verified. MEPED covers must be removed slowly to prevent rupture of the thin foil by pressure difference.

(c) Prior to the launch, the SEM will be turned OFF.

(d) During all modes, temperature operating limits will be observed for MEPED & TED of -15 to +25°C, and DPU -15 to +35°C.

(e) During prelaunch testing the TED Red Inhibit Plug must be installed

(f) During launch the TED Green Plug must be installed.

During prelaunch and launch modes, the TED's temperature will be controlled by the spacecraft Thermal Control Electronics which will turn on at -15°C. The TCE heater on the MEPED bracket will turn on at -12°C.

18.5.4.3 Depressurization Mode

Before the SEM can be turned ON, it must have been in the hard space vacuum for a minimum of 10 days to allow release of entrapped gases from the instruments.

18.5.4.4 Activation Mode

The activation mode constraints are as follows:

(a) The depressurization is completed.

(b) The spacecraft checkout is completed.

(c) The SEM temperature and voltage values are within limits.

(d) The low-voltage power supply must be commanded on first, or other commands will not be executed.

(e) All high-voltage power supplies control registers must be reset the turned ON.

18.5.4.5 Calibration Mode

In Flight Calibration (IFC) for TED and MEPED may be commanded ON simultaneousl but if one is commanded ON and the other commanded ON without a waiting period of a least 16 min, erroneous data will result.

18.5.4.6 Mission Mode

The Mission mode constraints are as follows:

(a) SEM activation and evaluation successfully completed and SEM operating in the Mission Mode configuration.

(b) SEM turnover to NOAA/NESS for operations in the Mission Mode.

18.6 DATA COLLECTION SYSTEM

18.6.1 FUNCTIONAL DESCRIPTION

18.6.1.1 Introduction

The Data Collection System (DCS) is one of the environmental monitoring systems to be flown on the TIROS-N series of spacecraft. The DCS will assist NOAA in its overall environmental mission and in support of the Global Atmospheric Research (GARP) Program. It is planned to have 2000 environmental platforms located around the Earth to measure such environmental factors as temperature, pressure, and currents. Some of these platforms will be immersed in a moving fluid, such as the ocean and the atmosphere. These moving platforms, buoys and balloons, will provide additional environmental information on velocity and direction of the ocean and wind currents.

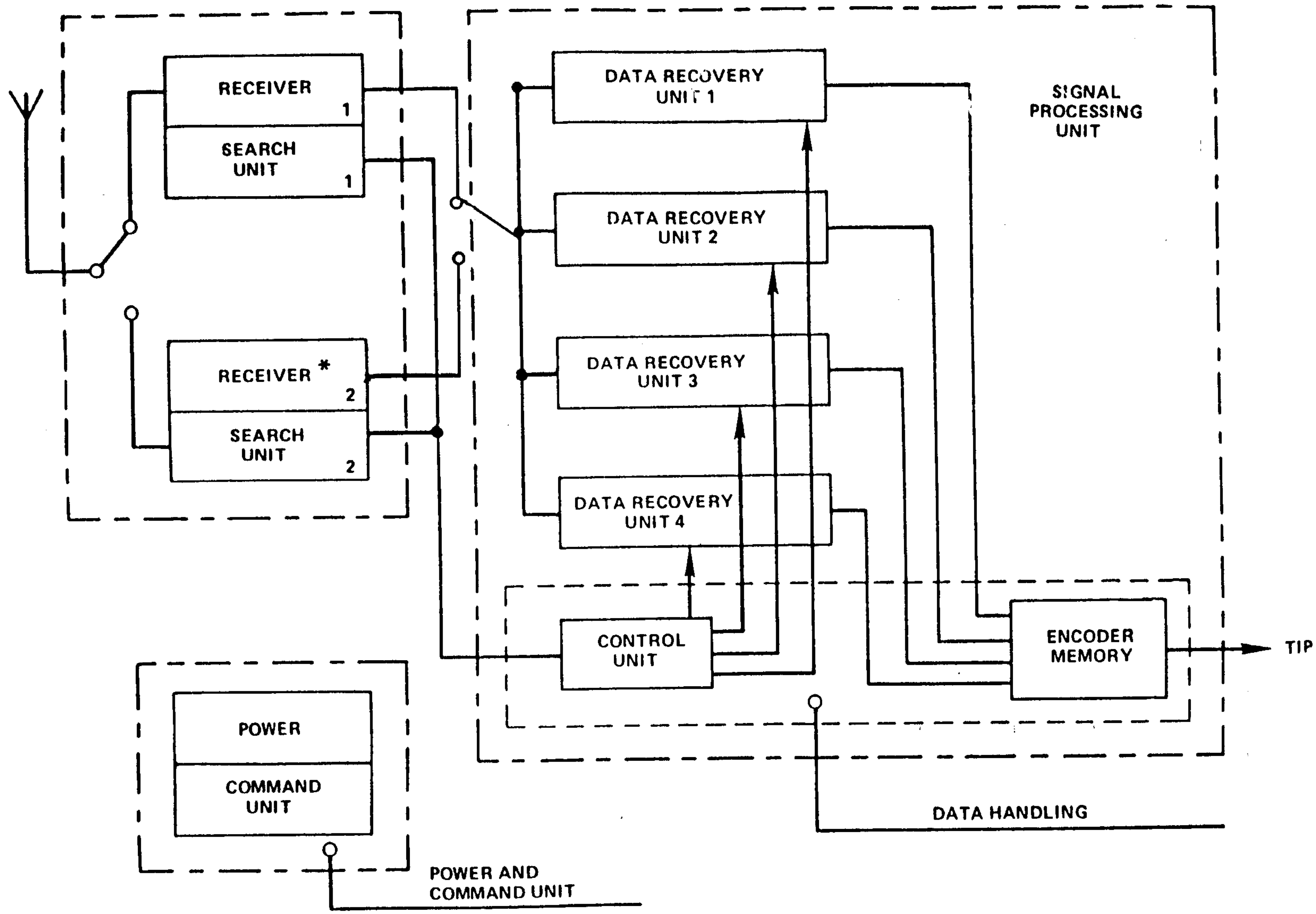
The DCS will receive information from these fixed and moving environmental platforms and will process and transfer the data for storage by the spacecraft tape recorders. These stored data will be transmitted to a TIROS-N ground station during station contact. The ground station will record and transmit the DCS data to the French Centre National D'Etudes Spatiales (CNES). CNES is the responsible manufacturing system engineering and data distribution agency for the DCS.

18.6.2 SYSTEM DESCRIPTION

18.6.2.1 General

The DCS is comprised of three units: (1) the receiver and search unit, (2) the signal processor unit, and (3) the power and command unit. The DCS block diagram is shown in Figure 18.6-1. The platforms transmit data to the DCS at a carrier frequency of 401.650 MHz, digital bilevel format at 400 bps. The DCS demodulates this signal and determines the intermediate frequency and relative time of each transmission. These data are processed, formatted, and transferred to TIROS-N Information Processor (TIP). The following paragraphs describe how the processing occurs in each of the DCS units.

18.6.2.1.1 Receiver and Search Unit-The receiver and search units are redundant and switchable on ground command. The characteristics of the input signal to the receiver are shown in Table 18.6-l. The receiver linearly converts the incoming signal by means of two translations to an intermediate frequency which is applied to the input of the



* Redundant Reciever is not used on NOAA-H, I, and J

Figure 18.6-1. DCS Block Diagram

search unit and to the Data Recovery Units. The Receiver Functional Block Diagram is shown by Figure 18.6-2. The search unit is basically a spectrum analyzer which simultaneously sweeps four channels each 6 kHz wide spaced so as to cover the operating frequency range. A fifth channel detects a very stable calibrating signal that was injected at the receiver's front end and compares it with a reference voltage. Any change in the signal voltage level provides an error gain control signal for the IF amplifiers in the receiver. Figure 18.6-3 shows the functional block diagram of the Search Unit.

TABLE 18.6-1. INPUT SIGNAL CHARACTERISTICS

Frequency • frequency range • doppler	401.650 MHz ±12 kHz <80 Hz/s
Level • dynamic range • minimum signal to noise ratio	-128 dBm to 109 dBm 19 dB 43 dB-Hz
Modulation - BϕL • bit frequency • stability • modulation index	400 ± 5 Hz $<10^{-3}$ 1.1 ± 0.1 rd

Message construction:

160 ms	111111111111111	00010111	1	24 bits	n x 32 bits
C.W.	B.S.	F.S.		IDENT.	n = 1, 2 . . 8 Sensor Data

18.6.2.1.2 Control Unit (CU)—The control unit sequentially scans the four SU channels. It makes a binary estimate of both the signal level and frequency. These two digital words are stored in the CU and are used for the assignment of a Data Recovery Unit (DRU) to a particular receiver output signal.

18.6.2.1.3 Data Recovery Unit (DRU)–The Data Recovery Unit is comprised of three sections: (1) phase-locked loop, (2) bit synchronizer, and (3) Doppler counter and formatter. The four DRU's perform the following signal functions: acquisition of the carrier, signal demodulation, bit synchronization, frame synchronization, Doppler counting, decommutation, and formatting of the data. Figure 18.6-4 shows the DCS Data Output Format.

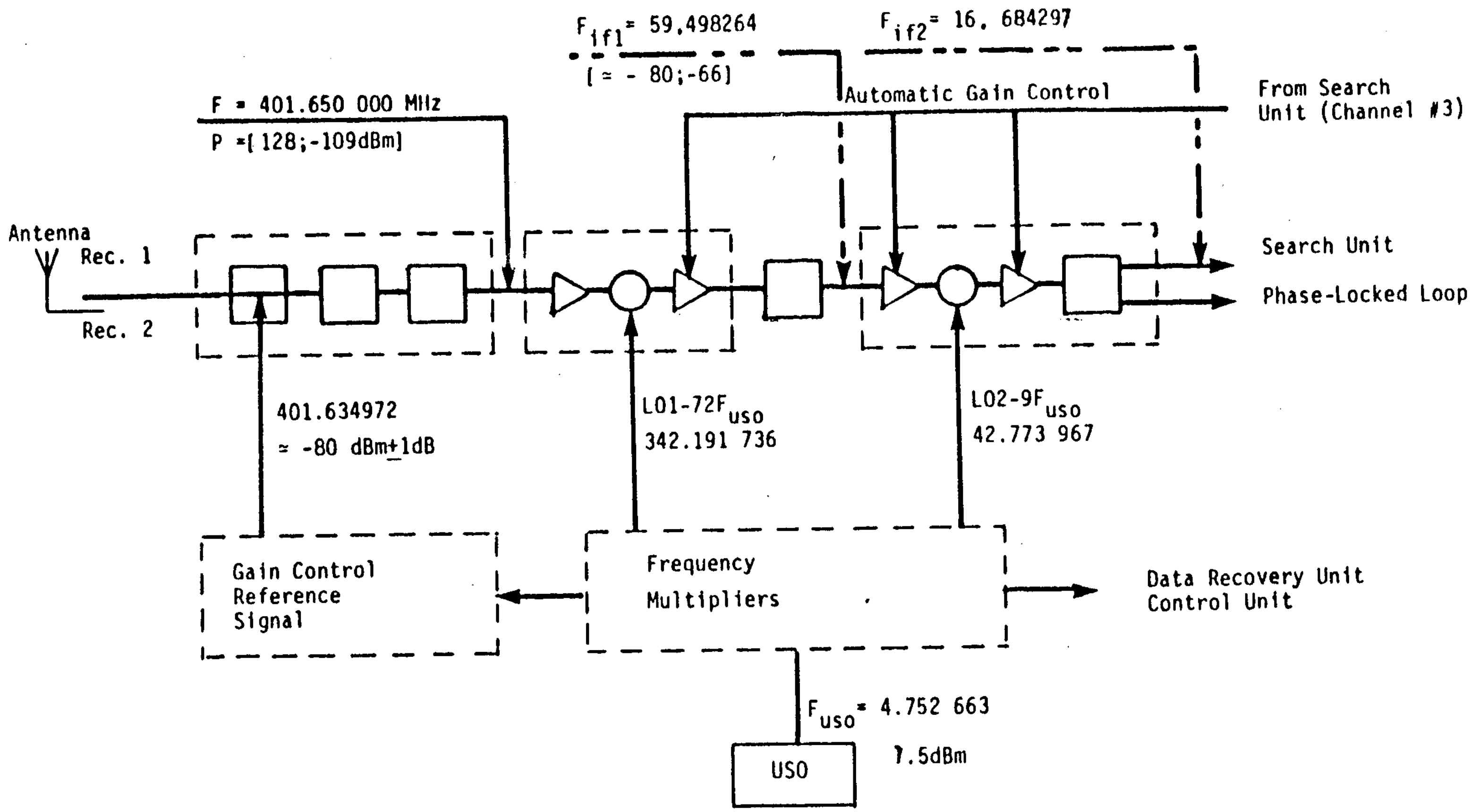


Figure 18.6-2. Receiver Block Diagram

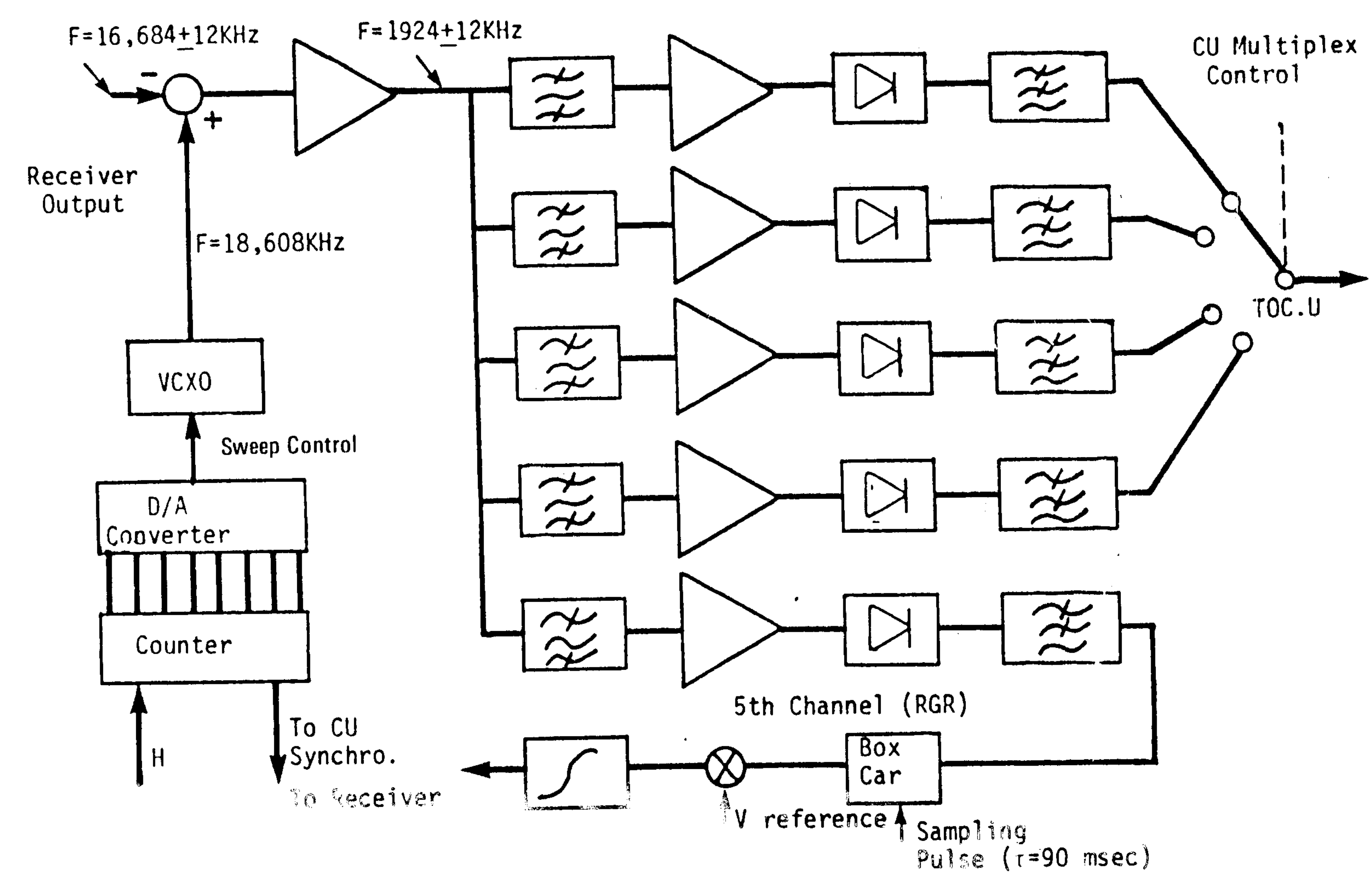
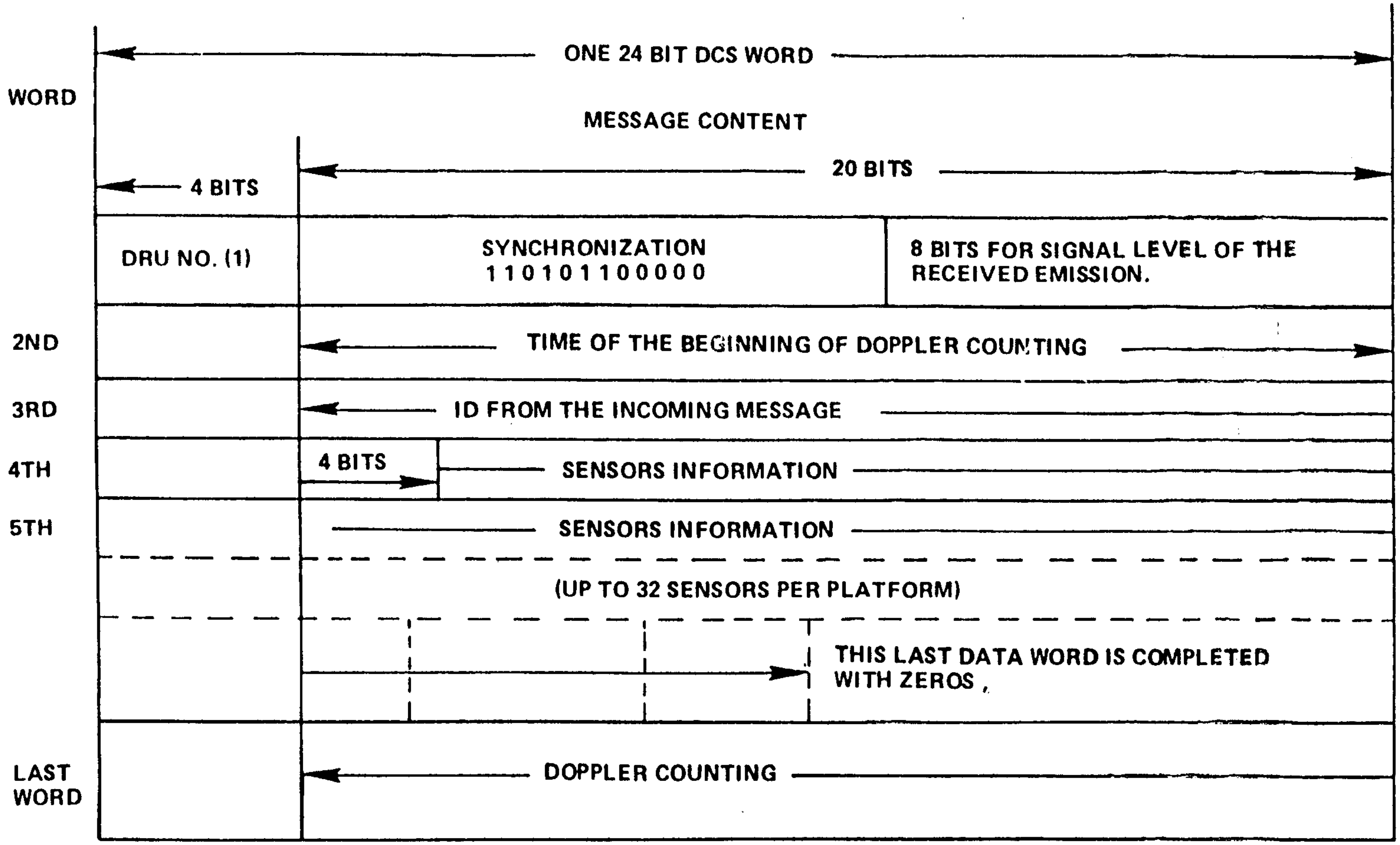


Figure 18.6-3. Search Unit Block Diagram



NOTES: 1. THE FOUR (4) ID BITS, WHICH IDENTIFY THE DATA RECOVERY UNIT, ARE THE FIRST FOUR BITS TRANSFERRED TO THE TIP.

2. A FULL PLATFORM MESSAGE HAS A MAXIMUM OF 17 DCS WORDS.

Figure 18.6-4. DCS Data Output Format

18.6.2.1.4 Telemetry Encoder and Memory-The telemetry encoder interrogates the buffer in the DRU's. When the buffer is full, the encoder sends a command to shift the 24 bits into memory. When the data transfer signal from TIP is received by the encoder, it will transfer the data out of memory to TIP. Figure 18.6-S shows the functional block diagram of the Telemetry Encoder and Memory.

18.6.2.1.5 Power and Command Unit-Power for the DCS is supplied by the spacecraft +28 V main power bus. This voltage is converted by the power unit to four levels; +5.0, +12, -12, and -15 V. Regulation and current limitation is provided for each of these DCS's buses. The command unit consists of seven relays which perform the ON/OFF functions for the DCS. The CIU sends pulse commands which control these relays. The command unit sends back to TIP 14 status bits and six analogs.

18.6.2.2 DCS Data

18.6.2.2.1 General-The output data from DCS are of three types: digital-A data, digital-B, and Analog telemetry.

18.6.2.2.2 Digital-A Data-The digital-A data are clocked into the spacecraft TIP whenever the A-data enable pulse is received by the DCS encoder. The digital-A output of the DCS consists of twelve 8-bit TIP words per minor frame. One DCS word consists of 20 bits of data plus 4 ID bits. Thus, 24-bit words are stored in the DCS for readout of 3 TIP 8-bit words. For a full 32 sensor platform message, 51 TIP words are utilized. Figure 18.64 shows the DCS data output format.

18.6.2.2.3 Digital-B-There are 10 bilevel digital-B status points that are sampled by the 3.2-sec subcom of the TIP. Minor frame word 8 is used for providing the DCS digital-B status. Table 18.6-2 lists the DCS digital-B telemetry points.

18.6.2.2.4 Analog Telemetry-The DCS analog telemetry will be available at the DCS/TIP interface. The DCS analog telemetry will be clocked into the TIP telemetry 32-sec subcom word 9. The DCS Analog Telemetry Chart is shown by Table 18.6-3.

18.6.3 MODES OF OPERATION

18.6.3.1 Prelaunch and Launch

This mode establishes the GO/NO GO condition of the DCS. Successful completion of final flight tests for launch is required. The DCS will be in the OFF

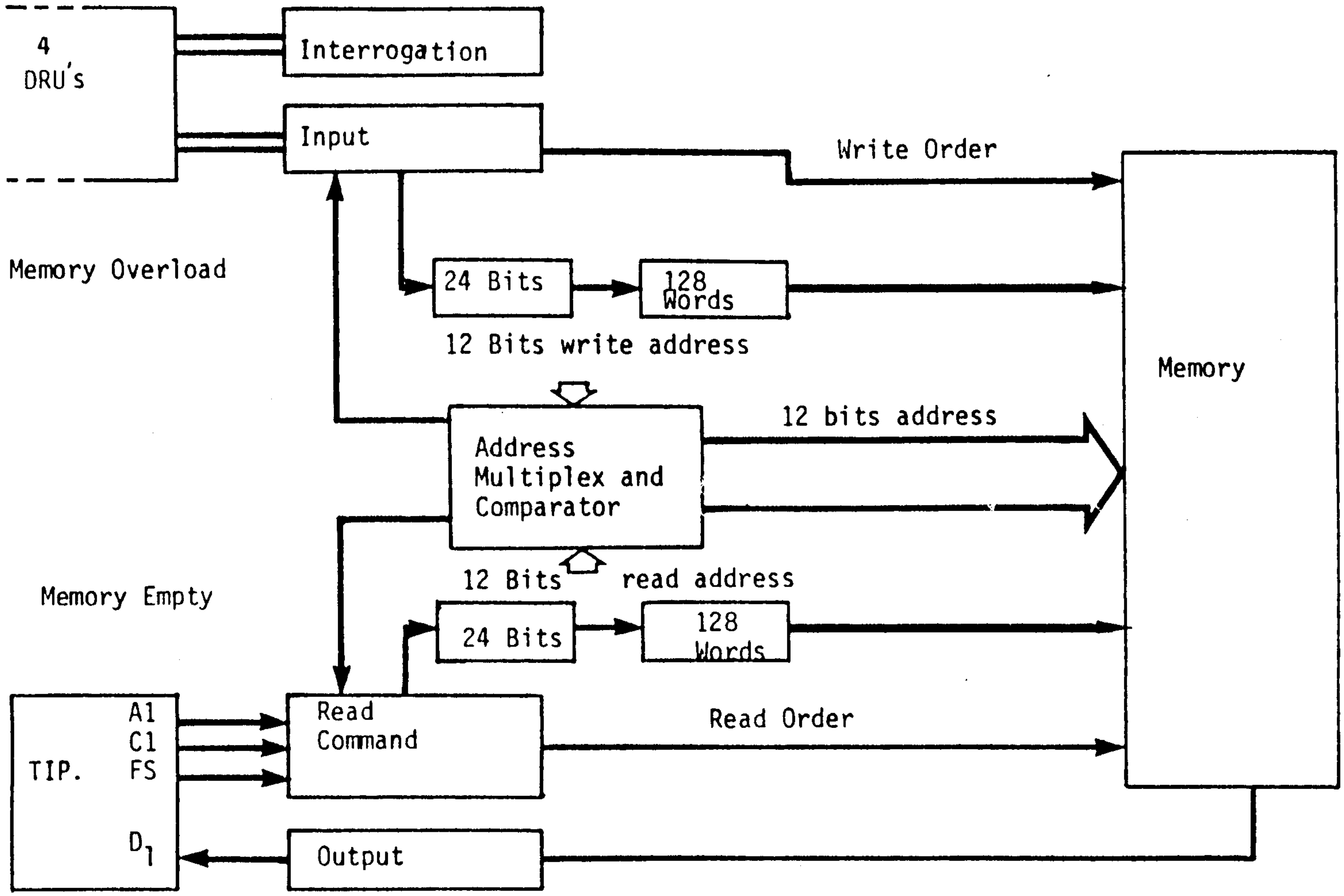


Figure 18.6-5. Telemetry Encoder and Memory Block Diagram

TABLE 18.6-2. DCS DIGITAL-B TELEMETRY

No.	Telemetry Point Name	State *		TIP		
		Logic "0"	Logic "1"	Minor Frame	Channel Number	Word 8 Bit #
1	DCS Relay A Status	ON	OFF	27	251	8
2	DCS Relay B Status	ON	OFF	28	28	1
3	DRU 1	ON	OFF	28	60	2
4	DRU 2	ON	OFF	28	92	3
5	DRU 3	ON	OFF	28	124	4
6	DRU 4	ON	OFF	28	156	5
7	Receiver	Receiver 1	Receiver 2	28	188	6
8	Antenna Coaxial Relay Position	Receiver 1	Receiver 2	28	220	7
9	Memory Overflow (>3072 bits)	**	**	28	252	8
10	DCS Time Code (MSB)	-	-	29	29	1

Notes: * Logic "0" or "High Voltage" state (5$\pm$.7V) is "ON". This convention is just the opposite of the convention used by the other spacecraft instruments.

** The state (Logic "0" or Logic "1") of TLM pt. #9 does not, by itself, indicate memory overflow. The occurence of memory overflow is indicated by a change in state of this bit.

TABLE 18.6-3. DCS ANALOG TELEMETRY

No.	Telemetry Point Name	TIP		
		Subcom	Minor Frame	Ch.#
1	Receiver Unit Temp.	32	175	175
2	US Oscillator #1 Temp.	32	55	55
3	US Oscillator #2 Temp.	32	63	63
4	USO #1 Thermal Reg. Voltage	32	71	71
5	USO #2 Thermal Reg. Voltage	32	79	79
6	Receiver #1 Gain Reg. Voltage	32	87	87
7	Receiver #2 Gain Reg. Voltage	32	95	95
8	Signal Processing Unit Temperature	32	167	167
9	Power & Cmd. Unit Temp.	32	47	47
10	Power Converter Temp.	32	39	39
11	PC +5 Voltage	32	238	238
12	PC +12 Voltage	32	15	15
13	PC -12 Voltage	32	23	23
14	PC -15 Voltage	32	31	31

mode for launch. Temperatures will be maintained within limits during the launch phase by the spacecraft thermal control electronics.

18.6.3.2 Spacecraft Activation Mode

The DCS will remain in the OFF mode until the spacecraft systems have been activated and evaluated. It is planned that the DCS will be turned 'ON approximately three weeks after orbit insertion.

18.6.3.3 Activation

This mode is the sequential turn ON and evaluation of the DCE. The sequence of events required to establish this mode are contained in para 18.6.5.

18.6.3.4 Mission Mode

This mission mode is started after the DCS has successfully completed the activation mode. This is the mode that the DCS will remain in during its operational life.

18.6.3.5 DCS OFF Mode

This is the sequential turn OFF mode for the DCS. This mode will not be established unless major difficulties occur with the DCS or spacecraft. Before turn OFF or the reduction of any DCS capabilities, the DCS Project Office concurrence must be obtained.

18.6.4 CONSTRAINTS

18.6.4.1 General

The various modes of operation have specific requirements (constraints) that must be complied with prior to the initiation of a mode. Once a mode has been established, additional constraints are required in order to maintain a safe mode. The termination of a mode also has specific constraints that must be met. The following constraints discussion is based primarily on the requirements as defined by the DCS specifications.

18.6.4.2 Prelaunch and Launch Mode

The prelaunch and launch mode is as follows:

(a) Dust covers removed.

(bj Successful completion of GO/NO GO Tests.

(c) DCS in OFF mode for launch.

(d) Launch Temperature.

18.6.4.3 Activation Mode

The activation mode is as follows:

(a) Minimum allowable time between DCS commands is 1 sec.

(b) Prior to turn ON, DCS temperature must be stable between +10°C to +30°C.

(c) A 120-min warm-up period after the DCS is commanded ON (DCS converter A/B ON) is required before the DRU's can be turned ON. Not more than two DRU's should be turned ON before warm-up is complete.

(d) DCS temperature limits during all modes of powered operations are -5°C to +45°C.

18.6.4.4 Mission Mdde

The mission mode is as follows:

(a) Activation mode has been successfully completed.

(b) DCS has been evaluated and is acceptable for turnover of responsibility to NOAA/NESS.

18.7 SARSAT INSTRUMENT PACKAGE

18.7.1 INTRODUCTION

General aviation aircraft are required to carry Emergency Locator Transmitters (ELTs), which are triggered by the impact of a crash and broadcast a signal at 121.5 and 243 MHz. These transmissions can be heard as sirenlike sounds on aircraft receivers of aircraft which may be overflying the transmitter. In addition, certain large ships are also required to carry 121.5 MHz Emergency Position Indicating Radio Beacons (EPIRBs) which also transmit the sirenlike sound. Some oceangoing vessels voluntarily carry the EPIRBs.

It has been recognized for many years that receipt of ground transmission; by overflying satellites includes a Doppler shift of the transmitted frequency due to the velocity of the satellite relative to the transmitter. This Doppler shift information can be used to locate the transmitter. The Search and Rescue (SAR) Instrument Package first flown on NOA 4-E and subsequent NOAA satellites carries a repeater for receiving and rebroadcasting the 121.5 and 243 MHz signals to a ground station where they can be detected and located by measuring their Doppler shift. However, these ELTs and EPIRBs were conceived prior to the satellite system and lack specifications which assure reliable detection through the satellite, Additionally, the SAR system is only functional when the spacecraft is within 1300 miles of a ground station. Even so, by the launch of NOAA-H, over 1000 people have been saved by SAR forces making use of satellite-derived alerts and locations.

A 406 MHz SAR system has been designed specifically to work with the satellite. The NOAA satellite SAR Instrument Package carries a 406 MHz processor which receives transmissions from 406 MHz ELTs and EPIRBs, recovers their digital message, measures the Doppler shift, and both stores the data for later transmission and also transmits it in real time, (A receiver/transmitter for the 406 MHz band is also included in the repeater for experimental purposes.) This new system utilizes distress transmitters (ELTs and EPIRBs) designed to be compatible with the satellite and the system provides full global coverage. The 406 MHz system was demonstrated and evaluated and declared ready for operational use by the time of the NOAA-H launch. Beginning with NOAA-H, the 406 MHz processor began utilizing a solid state memory for storage of the global data. Prior to NOAA-H, the processor used the spacecraft tape recorder for global storage.

18.7.2 GENERAL

The SARSAT Instrument 'Package consists of antennas/diplexer/filters, a repeater package, and a processor package as shown in Figure 18.7-l.

- SARSAT Antennas

  SRA receive antennas

  121.5/243 MHz
  406 MHz

  UDA receive antenna

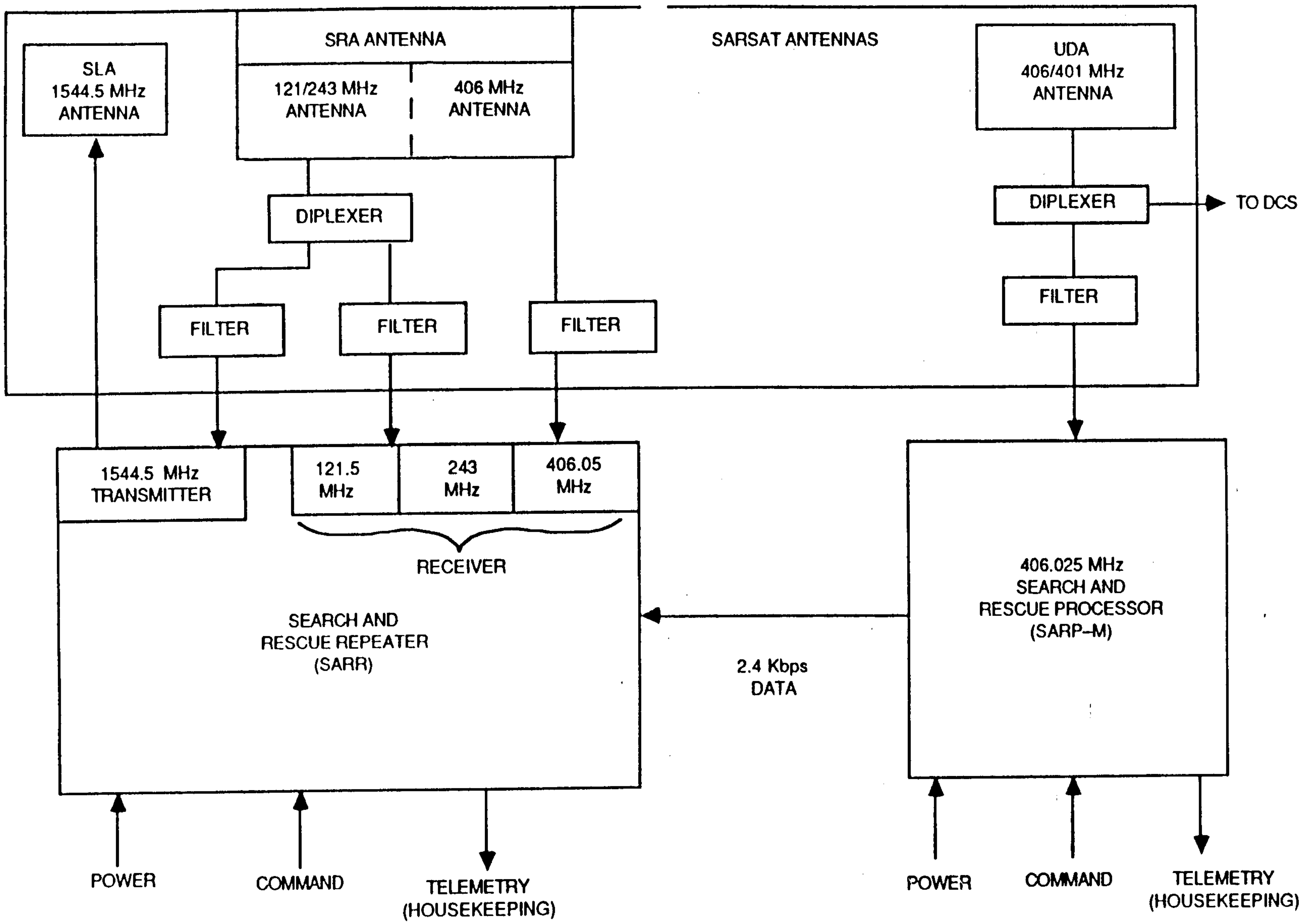


Figure 18.7-1. SARSAT Instrument Package

401.65/406.025 MHz

SLA transmitter antenna

1544.5 MHz

- Search and Rescue Repeater (SARR)

- SARP (Prior to NOAA-H) and SARP-M for NOAA-H and thereafter

The antennas/filters/diplexers and the SARR operate similarly on all models of NOAA spacecraft. The SARP and SARP-M provide different outputs, however. The SARP which is flown on spacecraft prior to NOAA-H provides a 2.4 kbps real-time data stream to the SARR for multiplexing into the 1544.5 MHz downlink transmitter, and stored data to the spacecraft tape recorder through the Manipulated Information Rate Processor (MIRP). The SARP-M which is flown on spacecraft NOAA-H and thereafter provides the stored data interleaved with the real-time data in the 2.4 kbps data stream sent through the 1544.5 MHz downlink transmitter.

The output of the SARSAT Instrument Package is four-frequency multiplexed signals on the 1544.5 MHz downlink transmitter:

(a) 2.4 kbps data

(b) 121.5 MHz band translated

(c) 243 MHz band translated

(d) 406 MHz band translated

In addition, prior to NOAA-H, the instrument package had the additional output of stored 406 MHz data through the MIRP. These data were also stored on spacecraft tape recorders. With NOAA-H and later satellites, the SARR instrument will output SARP-M data and data stored in the SARP memory.

The SARP-M 2.4 kbps data output consists of a Doppler frequency measurement, appropriately time-tagged and includes the SAR data message from the ELT/EPIRB.

For the regional coverage mode, 2.4 kbps real-time data are transmitted to a Lut via the SAR Repeater downlink. Global area coverage is provided by storing global 2.4 kbps data in a 406 Processor memory; these data are also transmitted to a Lut via the SAR Repeater downlink, but only during times when there is no regional coverage 2.4 kbps data to be transmitted.

18.7.3 SYSTEM DESCRIPTION

18.7.3.1 General

The orbiting SARSAT Instrument Package receives signals from ground-based ELTs/EPIRBs and returns them in both raw form and preprocessed form (406 MHz Experimental Units only) to one or more ground stations. Figure 18.7-1 shows the SARSAT Instrument Package which consists of three elements:

(a) SARSAT Antennas

(b) SAR -Repeater (SARR)

(c) SAR Processor (SARP-M)

18.7.4 SARSAT ANTENNAS

Figure 18.7-2 illustrates the antenna subsystem which consists of the:

(a) Search and Rescue Receiving Antenna (SRA)

(b) Data Collection System (DCS/UDA) Antennas

(c) L-band Transmitter Antenna (SLA)

18.7.4.1 SARSAT Receive Antennas

The SRA antenna feeding the SARR consists of two coaxial quadrifilar designs. The outer quadrifilar operates at two frequencies, 121.5 MHz and 243.0 MHz. The inner quadrifiiar operates at 406.05 MHz. The DCS/UDA antenna is a quadrifilar design and operates at 406.025 MHz for SARP/SARP-M and 401.650 MHz for the Data Collection System.

The SRA antennas are mounted on a boom which is deployed clear of the other spacecraft instruments, antennas, and solar array. There are four receive antenna ports for the SARSAT instruments, three for the SARR, and one for the SARP.

The 243 MHz and 406 MHz for both SRA and UDA receiving antenna patterns are shaped partially to compensate for increased signal path losses for ELTs at increasing distances from the subsatellite point. Table 18.7-1 lists the antenna parameters.

18.7.4.2 Transmitter Antenna

The L-band transmitter antenna is a small 1544.5 transmitter quadrifilar helix located on the Earth-facing side of the spacecraft which has single lobe pattern for full Earth coverage. There is one transmit antenna port for connection to the L-band transmitter of the SARR. Table 18.7-2 lists the antenna parameters.

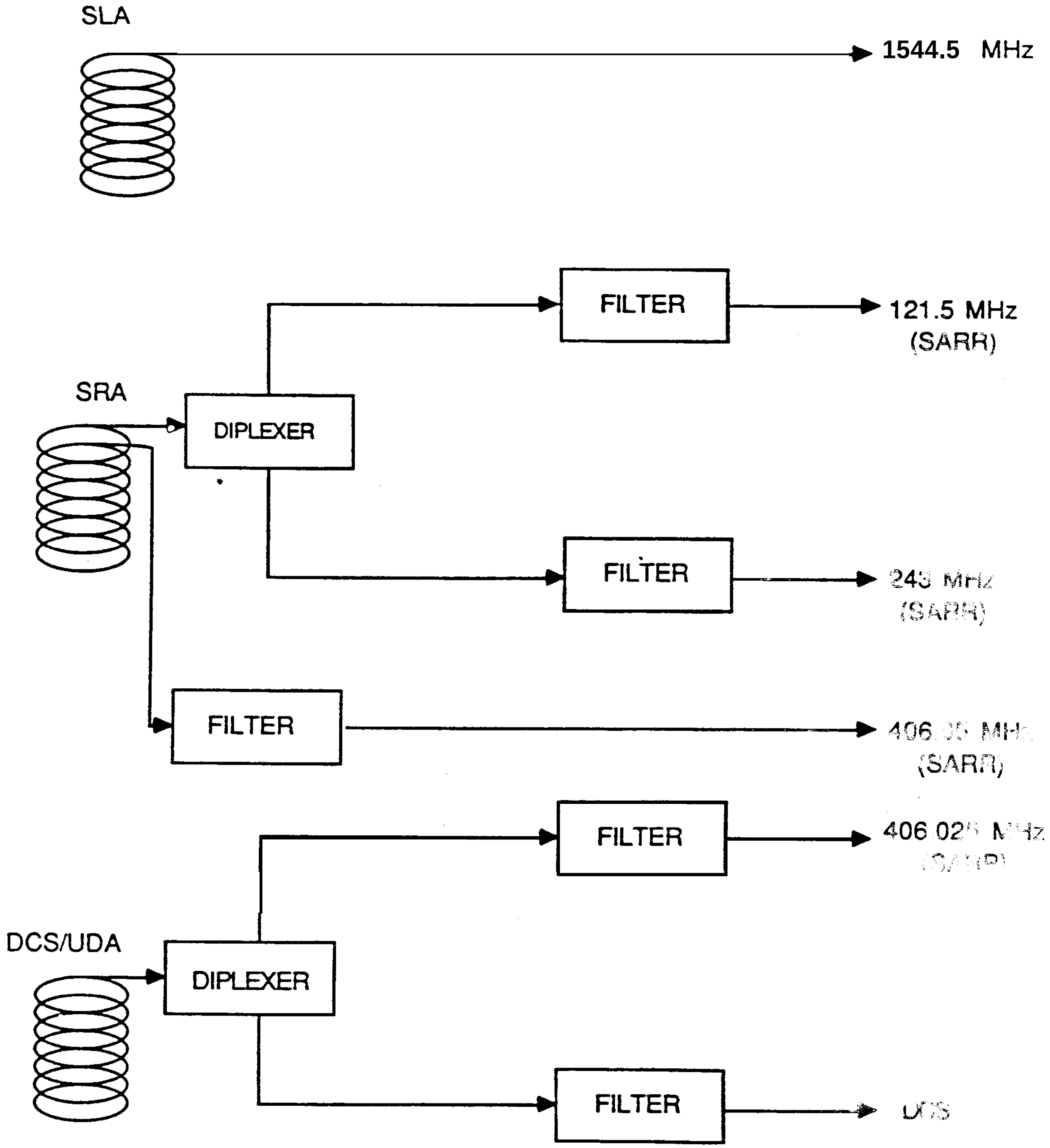


Figure 18.7-2. Antenna System Block Diagram

Table 18.7-I
SARSAT Receive Antennas Parameters

Parameters	Values
Operation Frequencies	SRA Antenna — 121.51, 243.0, 406.05 MHz DCS/UDA Antenna — 406.025 MHz
Minimum 1 dB Bandwidth	SRA. Antenna — 40 KHz at 121.5 MHz 60 KHz at 243.0 MHz 100 KHz at 406.05 MHz DCS/UDA Antenna — 40 KHz at 406.025 MHz
Spacecraft Emission Limits	

Max Signal Level (dBm)	121.5 MHz Band	243.MHz Band	406.05 MHz Band
-100	118.500-120.000	237.000-242.000	396401.000
-125	120.000-121.450	242.000-242.925	401.000-405.900
-145	121.450-121.485	242.925-242.975	405.900-406.000
-150	121.485-121.515	242.975-243.025	406.000-406.100
-145	121.515-121.550	243.025-243.075	406.100-406.200
-125	121.550-123.000	243.075-246.000	406.200411 .000
-100	123.000-124.500	246.000-249.000	411.000-416.000

Parameters	Values
VSWR	Less than 1.6:1
isolation	Greater than 20 dB at all frequencies.
Polarization	Right-hand circular
Axial Ratio and Gain Patterns	Contained in SARSAT Document No. D-l, SARSAT Spacecraft Antenna Specifications for 121.5 MHz, 243.0 MHz, 406.01 MHz, 406.05 MHz, 1544.5 MHz, Nov. 1979.

18.7.5 SAR REPEATER SUBSYSTEM

As shown in Figure 18.7-1, the SAR Repeater (SARR) subsystem receives the ELT/EPIRB signals on a 121.5, 243.0, and 406.05 MHz, downconverts to selected intermediate frequencies, remodulates this data, and retransmits on 1544.5 MHz (repeater data mode). The baseline concept is that each receiver is a dual conversion unit with AGC which converts the received bandwidth down to a frequency range between 35 kHz and 310 kHz. These bands are then summed with 2.4 K-bit data from the SAR 406 MHz processor and phase modulated on the 1544.5 MHz downlink carrier frequency. The modulation level of each band is independently

Table 18.7-2
SARSAT Transmit Antenna Parameters

Parameters	Values
Operation Frequency	1544.5 MHz
Bandwidth	± 1 MHz
Power Handling	10 Watts
VSWR	1:5:1
Polarization	Left-Hand Circular
Axial Ratio	4.5 dB in Coverage Region
Gain Patterns	Contained in SARSAT Document No. D-l, SARSAT Spacecraft Antenna Specifications for 121.5 MHz, 243.0 MHz, 406.01 MHz, 406.05 MHz, 1544.5 MHz, Nov. 1979.

adjustable to account for any long-term changes either in the operational procedures or the system noise environment. The system block diagram with commands and telemetry is shown in Figure 18.7-3.

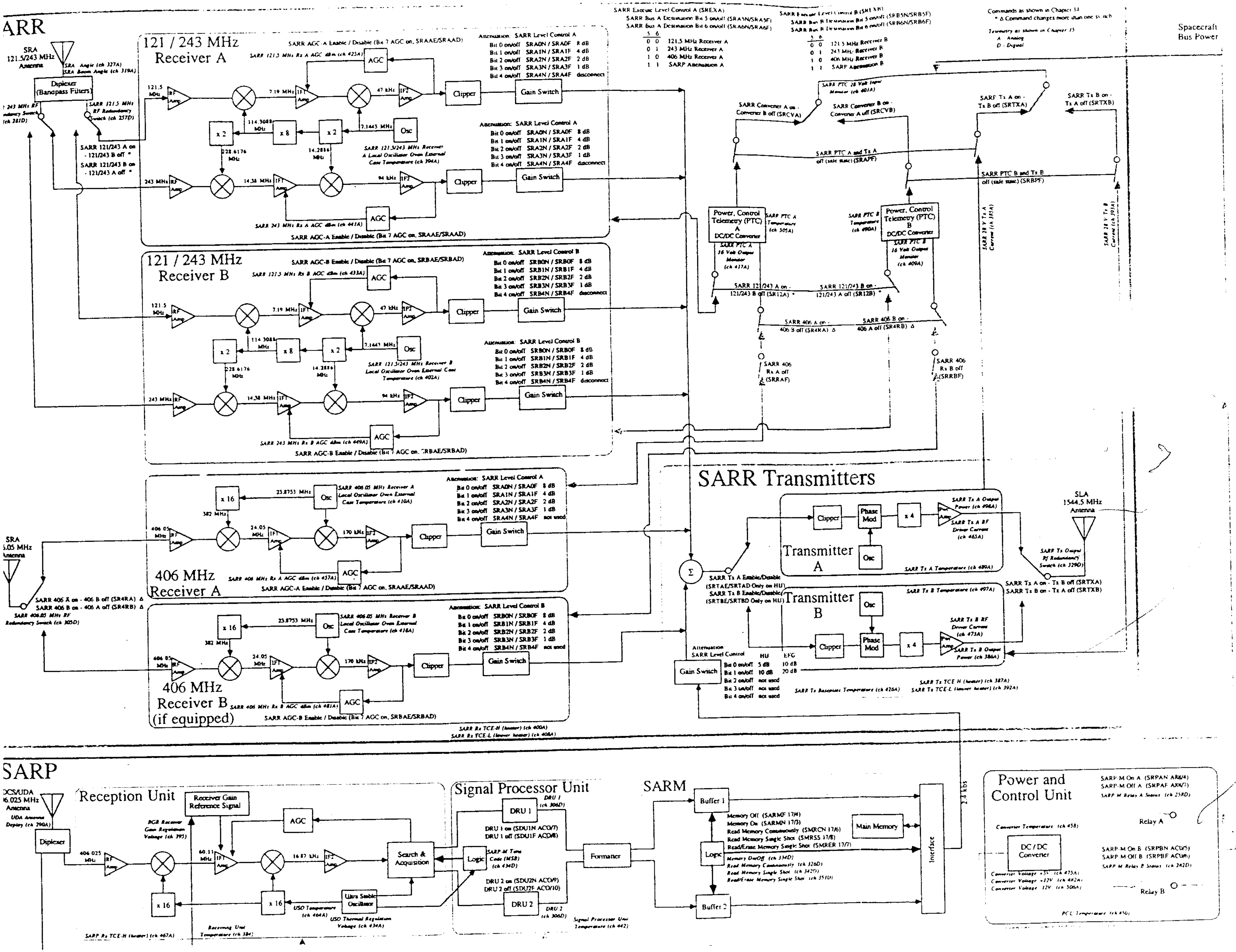
- SARR Input Parameters — Table 18.7-3 lists the Input Parameters.

- SARR Output Parameters — Table 18.7-4 lists the Output Parameters.

- SARR Transmission impairment Limits — Table 18.7-5 lists the Transmission Impairment Limits.

- SARR In-Orbit Adjustments — To optimize the system after initial on-orbit tests, a capability to adjust the power level of each converted frequency band prion to modulation on the downlink is provided. The nominal modulation indices for the four SARR channels are 0.232 radians rms, 0.464, 0.464, and 0.232 for the 2.4 kHzs, 121.5 MHz, 243 MHz, and 406 MHz channels, respectively. The composite modulation index is 0.734 radians rms.

Each channel includes a commandable attenuator that allows the modulation index to be varied independently, subject to the constraint that the composite rms modulation index shall not exceed 0.74 radians.



SARR
SRA 121.5/243 MHz Antenna
SRA Angle (ch 327A)
SRA Boom Angle (ch 319A)
Diplexer (Bandpass Filters)
SARR 121.5 MHz RF Redundancy Switch (ch 257D)
SARR 121/243 A on - 121/243 B off *
SARR 121/243 B on - 121/243 A off *
121 / 243 MHz Receiver A
SARR AGC-A Enable / Disable (Bit 7 AGC on, SRAAE/SRAAD)
SARR 121.5 MHz Rx A AGC dBm (ch 425A)
AGC
Attenuation: SARR Level Control A
Bit 0 on/off SRA0N / SRA0F 8 dB
Bit 1 on/off SRA1N / SRA1F 4 dB
Bit 2 on/off SRA2N / SRA2F 2 dB
Bit 3 on/off SRA3N / SRA3F 1 dB
Bit 4 on/off SRA4N / SRA4F disconnect
RF Amp
IF1 Amp
IF2 Amp
7.19 MHz
47 kHz
Clipper
Gain Switch
114.3088 MHz
x 2
x 8
7.1443 MHz
Osc
SARR 121.5/243 MHz Receiver A Local Oscillator Oven External Case Temperature (ch 394A)
228.6176 MHz
14.2886 MHz
243 MHz
14.38 MHz
94 kHz
SARR 243 MHz Rx A AGC dBm (ch 441A)
121 / 243 MHz Receiver B
SARR AGC-B Enable / Disable (Bit 7 AGC on, SRBAE/SRBAD)
SARR 121.5 MHz Rx B AGC dBm (ch 433A)
Attenuation: SARR Level Control B
Bit 0 on/off SRB0N / SRB0F 8 dB
Bit 1 on/off SRB1N / SRB1F 4 dB
Bit 2 on/off SRB2N / SRB2F 2 dB
Bit 3 on/off SRB3N / SRB3F 1 dB
Bit 4 on/off SRB4N / SRB4F disconnect
SARR 121.5/243 MHz Receiver B Local Oscillator Oven External Case Temperature (ch 402A)
SARR 243 MHz Rx B AGC dBm (ch 449A)
SARR Execute Level Control A (SREXA)
SARR Bus A Destination Bit 5 on/off (SRA5N/SRA5F)
SARR Bus A Destination Bit 6 on/off (SRA6N/SRA6F)
5 6
0 0 121.5 MHz Receiver A
0 1 243 MHz Receiver A
1 0 406 MHz Receiver A
1 1 SARP Attenuation A
SARR Execute Level Control B (SREXB)
SARR Bus B Destination Bit 5 on/off (SRB5N/SRB5F)
SARR Bus B Destination Bit 6 on/off (SRB6N/SRB6F)
0 0 121.5 MHz Receiver B
0 1 243 MHz Receiver B
1 0 406 MHz Receiver B
1 1 SARP Attenuation B
Commands as shown in Chapter 14
* Δ Command changes more than one switch
Telemetry as shown in Chapter 15
A - Analog
D - Digital
Spacecraft Bus Power
SARR PTC 28 Volt Input Monitor (ch 401A)
SARR Converter A on - Converter B off (SRCVA)
SARR Converter B on - Converter A off (SRCVB)
SARR Tx A on - Tx B off (SRTXA)
SARR Tx B on - Tx A off (SRTXB)
SARR PTC A and Tx A off (safe state) (SRAPF)
SARR PTC B and Tx B off (safe state) (SRBPF)
Power, Control Telemetry (PTC) A DC/DC Converter
SARR PTC A Temperature (ch 505A)
SARR PTC A 16 Volt Output Monitor (ch 417A)
Power, Control Telemetry (PTC) B DC/DC Converter
SARR PTC B Temperature (ch 490A)
SARR PTC B 16 Volt Output Monitor (ch 409A)
SARR 28 V Tx A Current (ch 385A)
SARR 28 V Tx B Current (ch 393A)
SARR 121/243 A on - 121/243 B off (SR12A) *
SARR 121/243 B on - 121/243 A off (SR12B) *
SARR 406 A on - 406 B off (SR4RA) Δ
SARR 406 B on - 406 A off (SR4RB) Δ
SARR 406 Rx A off (SRRAF)
SARR 406 Rx B off (SRRBF)
SRA 406.05 MHz Antenna
SARR 406 A on - 406 B off (SR4RA) Δ
SARR 406 B on - 406 A off (SR4RB) Δ
SARR 406.05 MHz RF Redundancy Switch (ch 305D)
406 MHz Receiver A
23.8753 MHz
x 16
382 MHz
SARR 406.05 MHz Receiver A Local Oscillator Oven External Case Temperature (ch 410A)
406.05 MHz
24.05 MHz
170 kHz
SARR 406 MHz Rx A AGC dBm (ch 457A)
SARR AGC-A Enable / Disable (Bit 7 AGC on, SRAAE/SRAAD)
Bit 4 on/off SRA4N / SRA4F not used
406 MHz Receiver B (if equipped)
SARR 406.05 MHz Receiver B Local Oscillator Oven External Case Temperature (ch 418A)
SARR 406 MHz Rx B AGC dBm (ch 481A)
SARR AGC-B Enable / Disable (Bit 7 AGC on, SRBAE/SRBAD)
Bit 4 on/off SRB4N / SRB4F not used
SARR Rx TCE-H (heater) (ch 400A)
SARR Rx TCE-L (lower heater) (ch 408A)
SARR Transmitters
Transmitter A
Phase Mod
x 4
Pwr Amp
SARR Tx A Output Power (ch 498A)
SARR Tx A RF Driver Current (ch 465A)
SARR Tx A Temperature (ch 489A)
SLA 1544.5 MHz Antenna
SARR Tx Output Rf Redundancy Switch (ch 329D)
SARR Tx A on - Tx B off (SRTXA)
SARR Tx B on - Tx A off (SRTXB)
Σ
SARR Tx A Enable/Disable (SRTAE/SRTAD Only on HU)
SARR Tx B Enable/Disable (SRTBE/SRTBD Only on HU)
Transmitter B
SARR Tx B Temperature (ch 497A)
SARR Tx B RF Driver Current (ch 473A)
SARR Tx B Output Power (ch 386A)
Attenuation SARR Level Control
HU EFG
Bit 0 on/off 5 dB 10 dB
Bit 1 on/off 10 dB 20 dB
Bit 2 on/off not used
Bit 3 on/off not used
Bit 4 on/off not used
SARR Tx Baseplate Temperature (ch 426A)
SARR Tx TCE-H (heater) (ch 387A)
SARR Tx TCE-L (lower heater) (ch 392A)
SARP
DCS/UDA 406.025 MHz Antenna
UDA Antenna Deploy (ch 290A)
Reception Unit
Receiver Gain Reference Signal
RGR Receiver Gain Regulation Voltage (ch 395)
406.025 MHz
60.11 MHz
16.87 kHz
Search & Acquisition
Ultra Stable Oscillator
USO Temperature (ch 464A)
USO Thermal Regulation Voltage (ch 434A)
x 16
SARP Rx TCE-H (heater) (ch 467A)
Receiving Unit Temperature (ch 384)
Signal Processor Unit
DRU 1
DRU 1 (ch 306D)
DRU 1 on (SDU1N ACO/7)
DRU 1 off (SDU1F ACO/8)
Logic
SARP-M Time Code (MSB) (ch 434D)
DRU 2 on (SDU2N ACO/9)
DRU 2 off (SDU2F ACO/10)
DRU 2
DRU 2 (ch 306D)
Signal Processor Unit Temperature (ch 442)
Formatter
SARM
Buffer 1
Buffer 2
Memory Off (SARMF 17/4)
Memory On (SARMN 17/3)
Read Memory Continuously (SMRCN 17/6)
Read Memory Single Shot (SMRSS 17/8)
Read/Erase Memory Single Shot (SMRER 17/7)
Main Memory
Memory On/Off (ch 33D)
Read Memory Continuously (ch 326D)
Read Memory Single Shot (ch 342D)
Read/Erase Memory Single Shot (ch 351D)
Interface
2.4 kbs
Power and Control Unit
SARP-M On A (SRPAN AX8/4)
SARP-M Off A (SRPAF AX8/3)
SARP-M Relay A Status (ch 258D)
Relay A
Converter Temperature (ch 458)
DC / DC Converter
SARP-M On B (SRPBN ACO/5)
SARP-M Off B (SRPBF ACO/6)
SARP-M Relay B Status (ch 242D)
Relay B
Converter Voltage +5V (ch 475A)
Converter Voltage +12V (ch 482A)
Converter Voltage -12V (ch 506A)
PCU Temperature (ch 450)

The 2.4 kHz channel is controllable in 5 dB steps, the 121.5, 243, and 406 MHz channels are controllable in 1 dB steps.

18.7.5.1 Commands

For "Level" commands, the "On," "True," or "Low" level output from the CXU is a logic "1" of zero-volt level. The "Off," "False," or "High" level output is a Logic ""0" or +10-volt level for CMOS logic.

The SARR requires 14 pulse discrete and 16 level discrete commands (EFG); 14-pulse, 18-level discrete (HIJ).

All commands will be implemented using the CIU Annex (CXU). The duration of each pulse will be 60 ± 5 milliseconds.

Table 18.7-3
SARR Input Parameters

Parameters	Values
Frequency	121.5, 243, 406.05 MHz
Bandwidth	25 KHz — 121.5 MHz 46 KHz — 243 MHz 80 KHz — 406.05 MHz
Signal Strength	-179 to -137 dBw — 121.5 MHz -182 to -149 dBw — 243 MHz -165 to -137 dBw — 406.05 MHz
Automatic Level Control	25 ms Attach 75 ms Decay
Transient Recovery Time	2 ms after removal of -60 dBw input signal at a [illegible] freq [illegible]
Processed Data	Retransmission of SARP-M data bit stream of 2.4 kbps, Coded BiϕL (SARP-M on NOAA-H and beyond is interleaved [illegible] and stored data. Prior to NOAA-H, only real-time data was transmitted through the SARR.)

Table 18.7-4
SARR Output Parameters

Parameters	Values
Frequency	1544.5 MHz
Frequency Stability	Long Term ± 1 part of 10^6 Short Term ± 1 part in 10^9 in 10 minutes
R.F. Power	8 watts minimum 10 watts maximum
Modulation Index	0.7 rad rrns 2.0 rad peak Peak to rms ratio $<$15 dB
Harmonics	50 dB below carrier power
Phase Jitter	Less than IO” rms at SO Hz bandwidth
RF Power Output (rms) Variation	± 5% for any combination of input signals or any type of input signal

The SARR wili survive any sequence of commands in any combination and rate. Normal test sequences will avoid switching of coaxial relay switches when the switch inputs are powered.

Further details on the functions of each command are given in Figure 18.7-3 and Table 18.7-6 and in the following paragraphs.

18.7.5.1.1 <u>SARR Level Control A Bit 0, Bit 1, Bit 2, Bit 3, and Bit 4</u>
These five level discretes together define the level of the data from the three “A” receivers and the SARP data received from the MIRP by the “A” PTC. They shall operate together with Bits 5 and 6 which define one of the four data sources to which Bits O-4 apply, and with the “SARR Execute Level Control A” pulse discrete which commands the SARR to decode Bits O-6 and assume the commanded state.

The meaning of Bits O-4 shall be different for the different data sources as follows:

(a) 121.5 MHz receiver and 243 MHz receiver. Bits O-3 shall form a binary number defining attenuation in decibels. Bit 0 shall be the most significant bit (MSB) with weight 8 dB; Bit 3 shall be the least significant bit (LSB) with weight 1 dB. Bit 4 shall provide receiver baseband signal output cutoff capability: when Bit 4 equals 1 the receiver shall pass the signal with the attenuation defined by Bits O-3; when Bit 4 equals 0 the receiver shall disconnect the signal from the transmitter.

Table 18.7-5
SARR Transmission Impairment Limits

Parameters	Values: Frequency	Values: Noise
Additive Noise Temperature Due to Spacecraft as Measured on NOAA-E	121.5 MHz 243 MHz 406.05 MHz	1500 K 700 K 300 K
Linearity	Less than −170 dBW for intermodulation products produced for two equal test tones of -90 dBW	
Gain Variation	± 1 dB within each frequency band	
Group Delay Slope	50 μs/KHz over 1 KHz band for 121.5 MHz 25 μs/KHz over 2 KHz band for 243 MHz 13 μs/KHz over 2 KHz band for 406 M Hz	
SARR Transmit Frequency Variation	Less than 1 part in 10^9 in any 10 minute period. Not more than 1 part in 10^6 over life of SARR .	
Image Rejection	RF — greater than 120 dB IF — greater than 80 dB	
Spurious Response	In band wideband spurious noise -- see additive noise Discrete spurious — less than −176 dBW at receiver input	

(b) 406.05 MHz receiver. Bit O-3 shall have the same meaning as in the 121 MHz and 243 MHz receivers. Bit 4 shall be meaningless.

(c) SARP data. Bits 0 and 1 shall define the attenuation setting in the PTC according to the code below. Bits 2-4 shall be meaningless.

Bit 0	Bit 1	Attenuation, dB (HIJ)	Attenuation, dB (EFG)
0	0	0	0
0	1	10	10
1	0	5	20
1	1	15	30

Table 18.7-6
Spacecraft — SARR Command Interface

Number	Command Name	Type
1	SARR Level Control A Bit 0	Level
2	SARR Level Control A Bit 1	
3	SARR Level **Control** A Bit 2	
4	SARR Level Control A Bit 3	
5	SARR Level Control A-Bit 4	
6	SARR Bus A Destination Bit 5	
7	SARR Bus A Destination Bit 6	
8	SARR Level Control B Bit 0	
9	SARR Level Control B Bit 1	
10	SARR Level Control B Bit 2	
11	SARR Level Control B Bit 3	
12	SARR Level Control B Bit 4	
13	SARR Bus B Destination Bit 5	
14	SARR Bus Destination Bit 6	
15	SARR AGC Disable/Enable A	
16	SARR AGC Disable/Enable B	
17	SARR Tx A On — Tx B Off	Pulse
18	SARR Tx B On — Tx A Off	
19	SARR Conv. A On — Conv. B Off	
20	SARR Conv. B On — Conv. A Off	
21	SARR 121/243 A On — 121/243 B Off	
22	SARR 1211243 B On — 121/243 A Off	Pulse
23	SARR 406 A On — 406 B Off	

Table 18.7-6
Spacecraft — SARR Command Interface (Continued)

Number	Command Name	Type
24	SARR 406 B On — 406 A Off	
25	SARR Execute Level Control A	
26	SARR Execute Level Control B	
27	SARR PTC A & Tx A Off	
28	SARR PTC B & Tx B Off	
29	SARR 406 A Off	
30	SARR 406 B Off	
31	SARR TXA Enable (HIJ only)	
32	SARR TXB Enable (HIJ only)	

The SARR shall not respond to changes in these level discretes. Rather, it shall respond to their state of the time it receives the pulse discrete command "SARR Execute Level Control A." The command receiving circuit is shown in Figure X.

18.7.5.1.2 SARR Bus A Destination Bit 5 and Bit 6 .

These two level discretes together shall define the destination of the level control commands defined by Bits O-4 and the destination of the AGC disable command as shown below.

Bit 5	Bit 6	Destination
0	0	121.5 MHz "A" receiver
0	1	243 MHz "A" receiver
1	0	406.05 MHz "A" receiver
1	1	SARP data attenuators in the "A" PTC

The SARR shall not respond to changes in these level discretes. Rather, it shall respond to their state at the time it receives the pulse discrete command, "SARR Execute Level Control A."

18.7.5.1.3 SARR Level Control B Bit 0, Bit 1, Bit 2, Bit 3, and Bit 4

The description in 18.7.5.1.1 shall apply, substituting "B" for "A."

18.7.5.1.4 SARR Bus B Destination Bit 5 and Bit 6

The description in 18.7.5.1.1 shall apply, substituting "B" for "A."

18.7.5.1.5 SARR AGC Disable/Enable A

The "0" state of this level discrete shall select fixed gain mode for the receiver designated by Bus A Destination Bits 5 and 6. The "1" state shall select AGC mode for that receiver.

The SARR shah ignore the state of this discrete if Bus A Destination Bits 5 and 6 are both "1." The SARR shall not respond to changes in this level discrete. Rather, it shah respond to the state of the discrete at the time the SARR receives the pulse discrete command "SARR Execute Level Control A."

18.7.5.1.6 SARR AGC Disable/Enable B

The description in the previous paragraph shah apply, substituting "B" for "A."

18.7.5.1.7 SARR Tx A On — Tx B Off

This command shah cause the SARR to connect the + 28 Volt Main Bus to the power input of the "A" transmitter and shah connect the rf output of that transmitter to the SLA. This command shall also cause the SARR to disconnect the +28 Volt Main Bus from the power input of the "B" transmitter. This command shall have no effect on the dc/dc converter residing in either PTC, and shall have no effect on any receiver.

18.7.5.1.8 SARR Tx B On — Tx A Off

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.1.9 SARR Converter A On — Converter B Off

This command shall cause the SARR to connect the + 28 Volt Main Bus to the power input of the dc/dc converter residing in the "A" PTC and to disconnect the +28 Volt Main Bus from the power input to the dc/dc converter residing in the "B" PTC. This command shall have no effect on the power status of either transmitter or on the state of any rf switch. The result of this command shall be to make secondary power available to the power inputs of the "A" receivers. However, other commands defined below shall determine whether or not those power inputs connect to the output of the dc/dc converter.

18.7.5.1.10 SARR Converter B On — Converter A Off

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.1.11 SARR 121/243 A On — 121/243 B Off

This command shall cause the SARR to connect the power input to the "A" 121/243 MHz receivers to the power output from the dc/dc converter residing in the "A" PTC. It shall also cause the SARR to connect the rf input to the "A" 121.5 MHz receiver to the SARR 121.5 MHz bandpass filter and thence to RFF-10/16[1] and the 121.5 MHz port of the SRA; it shall cause the SARR to connect the rf input to the "A" 243 MHz receiver to the SARR 243 MHz bandpass filter and thence to RFF-9/15[1] and the 243 MHz port of the SRA. The SARR shall disconnect the power input to the "B" 121/243 MHz receivers from the power output from the dc/dc converter residing in the "B" PTC. It shall disconnect the rf inputs of the "B" 121.5 MHz and 243 MHz receivers from the rf paths defined above. This command shall have no effect on the power On/Off status of the dc/dc converter residing in either PTC. It shall have no effect on the power status or rf connection of either transmitter.

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[1] 9, 10 (EFG); 15, 16 (HIJ)

18.7.5.1.12 SARR 1211243 B On —121/243 A Off

The description in the previous paragraph shall apply, substituting ''B'' for "A."

18.7.5.1.13 SARR 406 A OR — 406 B Off

This command shall cause the SARR to connect the power input to the "A" 406.05 MHz receiver to the power output from the dc/dc converter residing in the "A" PTC. It shall also cause the SARR to connect the rf input to the "A" 406.05 MHz receiver to the SARR 406.05 MHz bandpass filter and thence to RFF-8 and the 406.05 MHz port of the SRA.

The SARR shall disconnect the power input to the "B" -406.05 MHz (1) receiver from the power output from the dc/dc converter residing in the "B" PTC. It shall disconnect the rf input of the ''B'' 406.05 MHz receiver from the rf path defined above. This command shall have no effect on the power On/Off status of the dc/dc converter residing in either PTC. It shall have no effect on the power status or rf connection of either transmitter.

18.7.5.1.14 SARR 406 B On — 406 A Off

The description in the previous paragraph shall apply, substituting ''B'' for '"A.'"

18.7.5.1.15 SARR Execute Level Control A

This pulse discrete shall cause the SARR to execute the commands defined by the current state of all the "A" side level discretes, including level setting and AGC enable/disable. The SARR shall execute this command independent of its mode status, so long as the +28 Volt Main Bus and the + 10 Volt Interface Bus are present. Execution shall take the form of driving a set of latching relays in the PTC and the selected receiver. This command shall hav no effect on the "B" PTC or any "B" receiver. It shall have no effect on the power On/Off status or rf signal routing of any unit.

18.7.5.1.16 SARR Execute Level Control B

The description in the previous paragraph shall apply, substituting "B" for A."

18.7.5.1.17 SARR PTC A and Tx A Off

This command shall cause the SARR to disconnect the power input to the dc/dc converter residing in the "A" PTC and the "A" transmitter from the + 28 Volt Main Bus. [illegible] have no effect on any "B" unit or rf signal routing of any unit. It shall have [illegible] connections between the power output of either dc/dc converter and the power input to any receiver.

18.7.5.1.18 SARR PTC B and Tx B Off

The description in the previous paragraph shall apply, substituting ''B'' for "A"

18.7.5.1.19 SARR 406 A Off

This command shall cause the SARR to disconnect the power input to the "A" 406.05 MHz receiver from the power output from the dc/dc converter residing in the "A" PTC. This command shall have no effect on the On/Off power status of any other unit. It shall have no effect on the rf signal routing of any unit.

18.7.5.1.20 SARR 406 B Off

The description in the previous paragraph shall apply, substituting "B" for "A"

18.7.5.1.21 SARR Modes

The SARR command structure shall prevent all redundant units listed in Table 1 from being powered at once. The command structure shall assure that at most one member of each redundant pair of units is powered.

The command and signal routing structure shall allow cross-strapping of the "A" receivers with the "B" transmitter and the "B" receivers (1) with the "A" transmitter. It shall disallow a mixed set of receivers from **"A"** and "B." It shall disallow cross-strapping of the SARP data. It shall allow any of the three following units to be powered on or off independent of the power On/Off status of the other two:

- Either transmitter
- Either 406.05 MHz receiver
- The unit comprising the 121.5 MHz receiver and the 243 MHz receiver with the same letter designation as the 406.05 MHz receiver above.

Table 18.7-7 lists all On/Off power modes of all SARR units, the commands necessary to achieve the modes, and the effects those commands have on other units.

18.7.5.1.22 SARR Commands When the Spacecraft Enters Safe-State Mode

When the spacecraft Command and Control Subsystem senses certain anomalous conditions, it issues a-set of commands to the other spacecraft subsystems. The composite mode status that results from those commands is defined as Safe-State Mode. Safe-State Mode in general includes commanding spacecraft mechanical assemblies and latching relays to predetermined states, and then commanding most spacecraft components into low-power or OFF modes. The commands to SARR associated with entering Safe-Stte Mode will be as follows:

All SARR level discrete commands as defined in 18.7.5.1.1 through 18.7.5.1.6 will be set to "0."

Two pulse discrete commands will be sent-"SAR PTC A and Tx A OFF" and "SARR PTC B and Tx B OFF," as defined in 18.7.5.1.7 and 18.7.5.1.18.

No other pulse discrete commands will be sent to SARR as part of entering Safe-State Mode. Therefore, SARR will be an exception to the general practice of commanding latching relays into predetermined states. None of the SARR level attenuators, rf switches, or secondary power routing switches will be commanded as part of entering Safe-State Mode.

18.7.5.1.23 SARR TX A Enable/Disable (NOAA-H, -1, -J only)

The "0" state of this level discrete (+ 10 V) shall allow the A-side transmitter to be commanded "on." The "I" state (0 V) shall inhibit the "on" command or cause the A-side transmitter to turn "off" when powered.

18.7.5.1.24 SARR TX B Enable/Disable (NOAA-H, -1, -J only)

The description above, shall apply, substituting B for A.

Table 18.7-7
SARR On/Off Power Modes

Unit	Mode	Command(s)	Effect of Commands on Other Units
TX A	On & output connected to SLA	Tx A Enable Tx A On — Tx B Off	Turns off Tx B & disconnects Tx B output from SLA; no effect on any receivers or dc/dc converters
	Off	PTC A and Tx A off	Turns off power from all "A" units; no effect on any rf switches
	Off & output disconnected from SLA	Tx B Enable Tx B On — Tx A Off	No effect on either dc/dc converter or any receivers; powers "B" transmitter
Tx B	All above descriptions apply — interchanging A & B		
121/ 243 Rx A	On & inputs connected to SRA	Conv A On — Conv B Off; 121/243 Rx A On — 121-243 Rx B Off	Unpowers "B" dc/dc converter and all "B" receivers; no effect on either transmitter
	Power Off	Conv B On — Conv A Off	Unpowers all "A" receivers; powers "B" converter; no effect on any rf switches or either transmitter
	Power Off	PTC A and Tx A Off	Disconnects power from all "A" units; no effect on any rf switches
	Power Off & inputs disconnected from SRA	121/243 Rx B On — 121/243 Rx A Off	Connects power input to "B" 121/243 MHz receivers to power output from "B" dc/dc converter; connects SRA to rf inputs to "B" 1211243 MHz receiver; no effect on either transmitter
121/ 243	Rx B — All above descriptions apply — interchanging A & B		
406 Rx A	On & input connected to SRA	Conv A On — Conv B Off; 406 A On — 406 B Off	Unpowers "B" dc/dc converter and all "B" receivers; no effect on either transmitter

Table 18.7-7
SARR On/Off Power Modes (Continued)

Unit	Mode	Command(s)	Effect of Commands on Other Units
406 RXA	Power Off	Conv B On — Conv A Off	Unpowers all "A" receivers; powers "B" dc/dc converter; no effect on any rf switches or either transmitter
	Power Off	PTC A and Tx A Off	Turns off power from all "A" units; no effect on any rf switches
	Power Off	406 A Off	No effect on any other unit
	Power Off & input disconnected from SRA	406 B On — 406 A Off	Connects power input to "B" 406 MHz receiver to power output from "B" dc/dc converter; connects SRA rf inputs to "B" 406 MHz receiver; no effect on either transmitter
406	Rx B — All above descriptions apply — interchanging A & B		
PTC A	dc/dc converter On	Conv A On — Conv B Off	Unpowers "B" dc/dc converter and all "B" receivers; no effect on any rf switches or transmitters
	dc/dc converter Off	Conv B On — Conv A Off	Unpowers all "A" receivers; powers "B" dc/dc converter; no effect on any rf switches either transmitter
	dc/dc converter Off	PTC A and Tx A Off	Unpowers all "A" units; no effect on any rf switches
PTC B	— all above descriptions apply — interchanging A & B		

18.7.5.2 Digital "B" Telemetry

The Digital "B" one-bit status telemetry shall be available at the instrument interface at all times. The 3.2-second subcoms generated by the TIP will sample each Digital "B" Telemetry Point once every 3.2 seconds.

Words 8 and 12 of the Minor Frame will be dedicated to the sampling of Digital "B" telemetry from all spacecraft components.

18.7.5.2.1 Digital “B” Telemetry Points

Four digital “B” Telemetry Points are required by the SARR. The Digital “B” Telemetry Points provided by the SARR are shown in Table 18.7~8. A description of each telemetry point is provided below.

Table 18.7-8
SARR Digital “B” Telemetry

Number	Telemetry Point Name	Digital “B” Channel Number
1	SARR 121.5 MHz Redundancy Switch	257
2	SARR 243 MHz Redundancy Switch	281
3	SARR 406 MHz Redundancy Switch	305
4	SARR Tx Output RF Redundancy Switch	329

18.7.5.2.2 SARR 121.5 MHz RF Redundancy Switch

This point reports which of the two redundant 121.5 MHz receivers is connected to SARK J8, the interface with the 121.5 MHz RF filter, RFF-10 (EFG); RF-16 (HIJ).

This telemetry point provides valid data in all SARR modes. The telemetry circuit is shown in Figure X.

18.7.5.2.3 SARR 243 MHz RF Redundancy Switch

This point reports which of the two redundant 243 MHz receivers is connected to SARR J9, the interface with the 243-MHz RF filter, RFF-9, (EFG); RF-15 (HIJ).

This telemetry point provides valid data in all SARR modes. The telemetry circuit is shown in Figure X.

18.7.5.2.4 SARR 406.05 MHz RF Redundancy Switch

This point reports which of the two redundant 406.05 MHz receivers is connected to SARR J10, the interface with the 406.05 MHz RF filter, RFF-8, (EFG); RFF-14, (HIJ).

18.7.5.3 Analog Telemetry

The Analog Telemetry shall be available at the instrument interface at all times during which the instrument is on. Three different subcom types (32, 16, and 1 seconds) generated by the TIP will be used to sample all spacecraft analog telemetry. The Analog Telemetry points provided by the SARR are shown in Table 18.7-9. Descriptions of each telemetry point are detailed below. Twenty-two Analog Telemetry channels are required by the SARR to monitor the health of the instrument.

Table 18.7-9
SARR Analog Telemetry

Number	Telemetry Point Name	Analog Telemetry Channel Number	Analog Subcom	Minor Frame
1	SARR Tx A RF Driver Current	385, 465	16-2	1, 81
2	SARR Tx B RF Driver Current	393, 473	16-2	9, 89
3	SARR PTC 28 Volt Input Monitor	401	16-2	17
4	SARR PTC A 16V Output Monitor	417	16-2	33
5	SARR PTC B 16 Volt Monitor	409	16-2	25
6	SARR 121.5 AGC Volts Tx A	425	16-2	41
7	SARR 121.5 AGC Volts Rx B	433	16-2	49
8	SARR 243 AGC Volts Rx A	441	16-2	57
9	SARR 243 AGC Volts Rx B	449	16-2	65
10	SARR 406 AGC Volts Rx A	457	16-2	73
11	SARR 406 AGC Volts Rx B	481	16-2	97
12	SARR Transmitter A Temperature	489	16-2	105
13	SARR Transmitter B Temperature	497	16-2	113
14	SARR PTC A Temperature	505	16-2	121
15	SARR PTC B Temperature	490	16-2	106
16	SARR Tx A Output Power	498	16-2	114
17	SARR Tx B Output Power	386	16-2	2
18	SARR 121/243 Receiver A Local Oscillator Oven External Case Temperature	394	16-2	10
19	SARR 121/243 Receiver B Local Oscillator Oven External Case Temperature	402	16-2	18
20	SARR 406 Receiver A Local Oscillator Oven External Case Temperature	410	16-2	26

Table 18.7-9
SARR Analog Telemetry (Continued)

Number	Telemetry Point Name	Analog Telemetry Channel Number	Analog Subcom	Minor Frame
21	SARR 406 Receiver B Local Oscillator Oven External Case Temperature	418	16-2	34
22	SARR Tx Baseplate Temperature	426	16-2	42

18.7.5.3.1 SARR Tx A RF Driver Current

When Transmitter "A" is ON, this telemetry voltage shall be an analog of the dc current drawn by the transmitter "A" RF driver amplifier from the Transmitter "A" regulated power supply. When Transmitter "A" is OFF, this telemetry voltage shall be 0 ± 0.5 volts.

18.7.5.3.2 SARR Tx B RF Driver Current

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.3 SARR PTC 28 Volt Input Monitor

This telemetry voltage shall be an analog of the +28 Volt Main Bus voltage at the input to either or both PTCs, independent of SARR ON/OFF status.

18.7.5.3.4 SARR PTC A 16 Volt Output Monitor

This telemetry voltage shall be an analog of the PTC "A" dc/dc converter output voltage, independent of SARR ON/OFF status.

18.7.5.3.5 SARR PTC B 16 Volt Output Monitor

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.6 SARR 121.5 MHz Rx A AGC Volts

When 121.5 MHz Receiver "A" is powered, this telemetry voltage shall be [illegible] the gain control voltage to the 121.5 MHz Receiver "A" IF amplifiers. The analog [illegible] ship shall be independent of whether the receiver is in automatic-gain-control [illegible] gain mode. When 121.5 MHz Receiver "A" is unpowered, this telemetry voltage shall [illegible] ± 0.5 volts.

18.7.5.3.7 SARR 121.5 MHz Rx B AGC Volts

The description in the previous paragraph shall apply, substituting "B" for "A"

18.7.5.3.8 SARR 243 MHz Rx A AGC Volts

The description in the previous paragraph shall apply, substituting "243" for "121.5"

›.7.5.3.9 SARR 243 MHz Rx B AGC Volts

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.10 SARR 406.05 MHz Rx A AGC Volts

If the SARR contains a functional receiver in the 406.05 MHz Receiver A position, the description in 18.7.5.3.6 shall apply, substituting "406.05" for "121.5." If the SARR contains a dummy in the 406.05 MHz Receiver A position, this telemetry voltage shall be 0 ±0.5 volts.

18.7.5.3.11 SARR 406.05 MHz Rx B AGC Volts

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.12 SARR Tx A Temperature

When the +28 Volt Analog Temperature Telemetry Bus is ON, this telemetry voltage shall be an analog of the temperature of a point internal to Transmitter "A," located near the final RF power transistor. The analog relationship shall be independent of the SARR ON/OFF status. When the +28 Volt Analog Temperature Telemetry Bus is OFF, this telemetry voltage shall be 0 ±0.5 volts.

18.7.5.3.13 SAR Tx B Temperature

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.14 SARR PTC A Temperature

When the +28 Volt Analog Temperature Telemetry Bus is ON, this telemetry voltage shall be an analog of the temperature of a point in the dc/dc converter in PTC "A." The analog relationship shall be independent of the SARR ON/OFF status. When the +28 Volt Analog Temperature Telemetry Bus is OFF, this telemetry voltage shall be 0 ±0.5 volts.

18.7.5.3.15 SARR PTC B Temperature

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.16 SARR Tx A Output Power

When Transmitter "A" is ON, this telemetry voltage shall be an analog of the RF power from the final RF power transistor to the low-pass filter and output isolator in Transmitter "A." When Transmitter "A" is OFF, this telemetry voltage shall be 0 ±0.5 volts.

18.7.5.3.17 SARR Tx B Output Power

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.18 SARR 121.5 MHz/243 MHz Receiver A Local Oscillator Oven External Case Temperature

The Local Oscillator subassembly of the 121.5 MHz/243 MHz Receiver "A" assembly contains a crystal oscillator housed in a temperature-controlled oven. When the + 28 Volt Analog Temperature Telemetry Bus is ON, this telemetry voltage shall be an analog of the temperature of a point on the outside of the case of the temperature-controlled oven. The analog relationship shall be independent of the SARR ON/OFF status. When the +28 Volt Analog Temperature Telemetry Bus is OFF, this telemetry voltage shall be 0 ±0.5 volts.

18.7.5.3.19 SARR 121.5 MHz/243 MHz Receiver B Local Oscillator Oven External Case Temperature

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.20 SARR 406.05 MHz Receiver A Local Oscillator Oven External Case Temperature

If the SARR contains a functional receiver in the 406.05 MHz Receiver A position, the description in 2.3.3.18 shall apply, substituting "406.05 MHz" for "121.5 MHz/243 MHz." If the SARR contains a dummy in the 406.05 MHz Receiver A position, this telemetry voltage shall be 0.9 ±0.5 volts when the +28 Volt Analog Temperature Telemetry Bus in ON, and 0 ±0.5 volts when the +28 Volt Analog Temperature Telemetry Bus is OFF.

18.7.5.3.21 SARR 406.05 MHz Receiver B Local Oscillator Oven External Case Temperature

The description in the previous paragraph shall apply, substituting "B" for "A."

18.7.5.3.22 SARR Tx Baseplate Temperature

When the +28 Volt Analog Temperature Telemetry Bus is ON, this telemetry voltage shall be an analog of the temperature of a point near the center of the surface of the Transmitter Assembly Base Plate. The surface shall be that which faces the inside of the ESM. The analog relationship shall be independent of the SARR ON/OFF status. When the + 28 Volt Analog Temperature Telemetry Bus is OFF, this telemetry voltage shall be 0 ±0.5 volts.

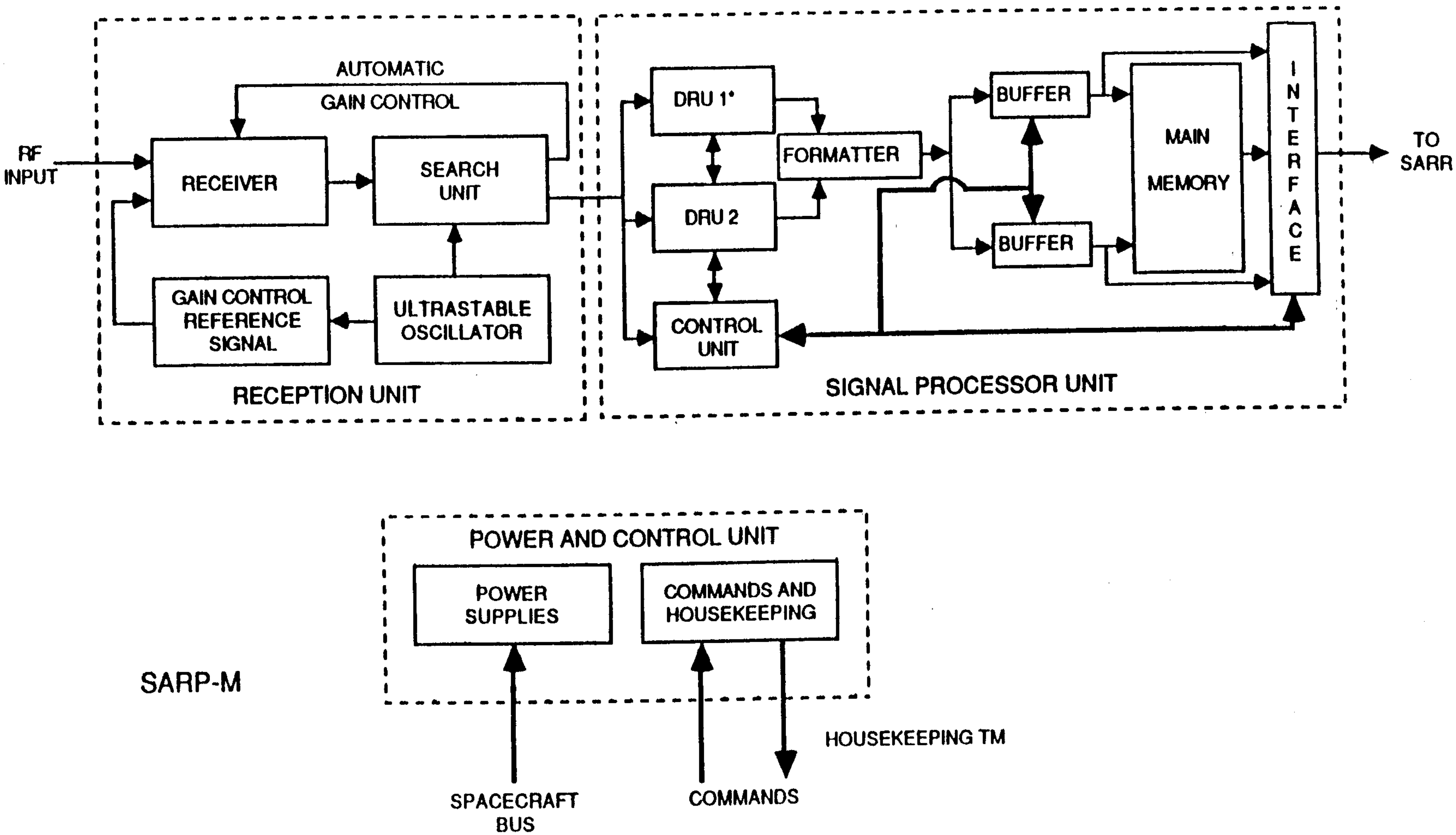
18.7.6 SAR PROCESSOR (SARP-M)

The 406 MHz on-board processor (see Figure 18.7-1) receives the 406 MHz transmissions from distress beacons and translates to an Intermediate Frequency (IF) using a double conversion. The IF signal is demodulated in a phase-lock loop to recover the data; the carrier frequency is measured and the data time tagged. For the regional coverage mode, real-time data are transmitted to a Lut via the SAR Repeater downlink. Global area coverage is provided by storing global data in a 406 Processor memory; these data are also transmitted to a Lut via the SAR Repeater downlink, but only during times when there is no regional coverage data to be transmitted.

18.7.6-l SARP-M Description

Figure 18.7-4 shows the block diagram of the 406 MHz Processor. The received signal is fed first to the Receiver Unit which utilizes a double conversion process to translate [illegible] to a lower frequency. The receiver is a constant gain type, linear over a 23 dB dynamic range. Gain is held constant by an Automatic Gain Control referenced to an internally generated reference signal fed into the receiver input offset from the expected signal bandwidth.

The Search Unit divides the 24 kHz processor operating range into four bands of 6 kHz each, which are searched simultaneously for received signals. The full 24 kHz band is searched in 90 ms. When a signal is detected the Control Unit assigns the signal to a Data Recovery Unit (DRU) on the basis of an algorithm designed to optimize the multiple-access performance. The algorithm for assignment is based on the frequency and level of the input to the receiver as well as the current assignment state of the DRUs.



* DRU - DATA RECOVERY UNIT

Figure 18.7-4. SARP-M Block Diagram

When a signal is assigned to a DRU, the Voltage Controlled Oscillator (VCO) is presteered to within the lock-in range by a voltage which is proportional to the signal frequency as determined by the Search Unit. After VCO lock-up, the signal is demodulated and fed to a bit synchronizer which supplies the clock for subsequent digital processing. When the clock is available, the sync word contained in the message is detected and the remaining digital message processed. Doppler frequency is determined by counting the VCO signal for a specified time interval; the time at which the Doppler measurement is made is determined by using a time base referenced to the Processor Ultrastable Oscillator.

The Processor Formatter outputs a composite message made up of either eight 24-bit words for a short message or nine 24-bit words for the long message to the Processor Memory. The expected message length is determined by the Processor by detecting a single bit fla-g indicating message length contained in the received message from the experimental ELT/EPIRB.

The formatted message output is sent to the main memory and to the interface unit where it is transferred to the SARP 2.4 kbps input port.

The- processor is implemented physically into three units with a total weight of 16.10 kg, and a total volume of 28.6 liters. Power consumption is 13.93 watts.

18.7.6.2 SARP-M Output Message Formatting

The basic unit for transmission of SARP-M data is a 24-bit word. A "frame" of data consists of 50 24-bit words, and the first word (frame sync word) of each frame is always "42BB1F."

The 24-bit words are organized into messages either 8 words for a short message or 9 words for a long message. The words belonging to a given message will always be transmitted consecutively, except that the frame sync word (42BB1F) will be inserted between two words of the same message at the beginning of a frame if the message is not completed in the previous frame. The SARP-M will operate in one of three modes: real-time, playback, and real-time interleaved with playback messages.

Whenever the memory is ON, incoming messages received into the memory unit are simultaneously transmitted directly (real-time messages) and stored in the memory for subsequent transmission (playback messages). Playback messages are always transmitted on a Last In First Out (LIFO) basis. When any one of the playback (Read Memory) modes is active, there will be continuous transmission of stored messages (LIFO), one immediately following another. Playback message transmission will be interrupted if a new message becomes available for real-time transmission, but only upon completion of transmission of the current playback message. Following real-time transmission (and storage) of the new message, playback transmission will resume where it left off. If the memory is filled, the new message will overwrite the oldest stored message.

If none of the playback modes is active and no messages are available for real-time transmission, filler or "zero" words are transmitted. The zero word consists of "0" for each of the first 23 bits and "1" for the 24th (000001 in hexadecimal).

If any one of the Read commands is received by the SARP-M during the transmission of a message, transmission of that message will be completed, and then the mode indicated by the Read command will be implemented (with playback starting with the most recent message stored in the memory).

The order of priority in selection of the next 24-bit word to be transmitted is therefore as follows:

(I) Transmit frame sync word (42BB1F) if this is the first word of a frame.

(2) Transmit the next word in a partially transmitted message.

(3) Transmit the first word of the most recent stored message if a Read command has been received but not implemented.

(4) Transmit the first word of a real-time message which has not been transmitted.

(5) Transmit the first word of the next most recent playback message.

(6) Transmit the first word of the most recent stored message if Read Continuously Mode is active and if the oldest playback message has just been transmitted. A zero word will precede resumption of playback.

(7) Transmit the zero word (000001).

The first 4 bits of each 24-bit word (except 42BB1F and 000001) have the following significance:

First: DRU which processed the message. "0" for DRU 1, "1" for DRU 2. (All words of each message come from the same DRU.)

Second: Always "0."

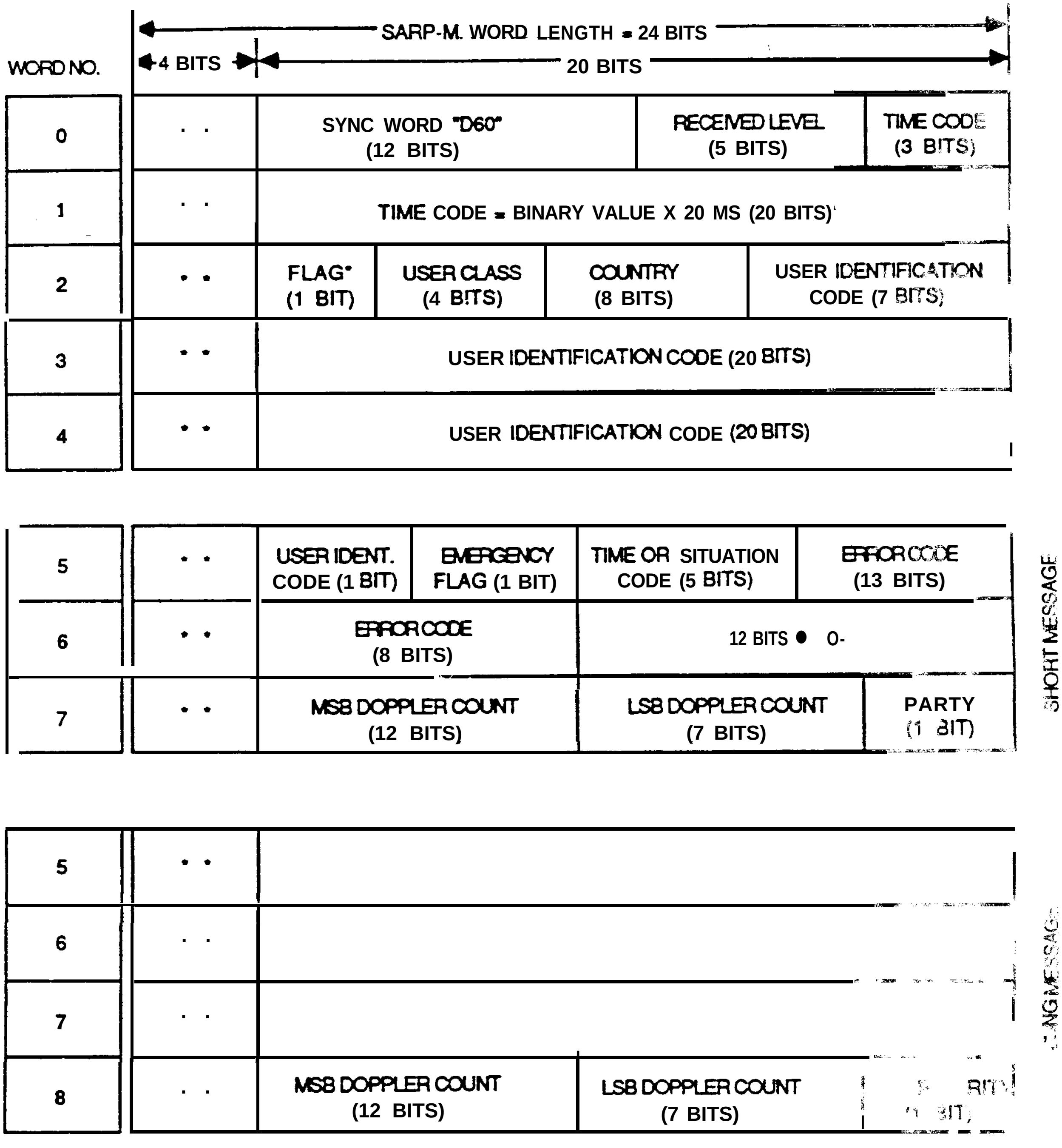
Third: Always "0" for real-time messages. For playback messages, it is "1" for the most recent message in storage, "0" for all other messages.

Fourth: Identifies real-time or playback message. "0" for playback, "1" for real time.

These bits are identical for all words in the same message.

The significance of the remaining 20 bits in each word of short and long messages for in-orbit operation is shown in Figure 18.7-S.

Data on the SARP-M output line is biphase L, code Manchester, at the 2400 Hz frequency. A bit "1" in the NRZ gives a 10 V down to 0 transition in the biphase (in the middle of the bit period). A bit "0" gives a 0 to 10 V up transition. The output level on the digital data line when the SARP-M is off and bus power is on will be a logic "0" (+ 10 V).



* FLAG: VALUE "0" INDICATES 88 BIT (SHORT) MESSAGE
VALUE "1" INDICATES 120 BIT (LONG) MESSAGE

** SEE: 18.7.6.2

Figure 18.7-5. Organization of a Message at the Output of the SARP-M

All messages (Real-time and playback) are output with words in the order shown in Figure 18.7-5, and the serial output of each word begins with the MSB (DRU No.).

18.7.6.3 SARP-M Input Message Format

The SARP-M input message format is shown in Figure 18.7-6. Either of the two formats for a long or short message can be utilized by an ELT/EPIRB for transmission to the spacecraft for location and identification of an emergency event.

18.7.6.4 SARP-M Parameters

SARP-M parameters are shown in Table 18.7-10.

18.7.6.5 SARP-M Commands

SARP-M commands are shown in Table 18.7-11 and in Figure 18.7-2.

18.7.6.6 Command Functional Summary

(1) SARP-M ON-A

Turns dc/dc converter “ON” via Relay A.

(2) SARP-M OFF-A

Turns dc/dc converter “OFF” via Relay A if Relay B is in “OFF” position.

(3) SARP-M ON-B

Turns dc/dc converter “ON” (Redundant) via Relay B.

(4) SARP-M OFF-B

Turns dc/dc converter “OFF” via Relay B if Relay A is in “OFF” position.

(5) DRU 1 ON:

Powers DRU 1 if Relay A or B is on.

(6) DRU 1 OFF:

Removes power from DRU 1.

(7) DRU 2 ON:

Powers DRU 2 if Relay A or B is on.

UNMODULATED CARRIER	BIT SYNC (1)	FRAME SYNC (2)	FORMAT FLAG (3)	
160 MS	15	9	0	87 BITS OF DATA

406 MESSAGE FORMAT (SHORT MESSAGE)

UNMODULATED CARRIER	BIT SYNC (1	FRAME SYNC (2)	FORMAT FLAG (3)	
160 MS	15	9	1	119 BITS OF DATA

406 MESSAGE FORMAT (LONG MESSAGE)

Notes: 1) BIT SYNC - 15 ‘1’ BITS
2) FRAME SYNC - 000101111
3) ● I” BIT INDICATES LONG MESSAGE FORMAT
"0" BIT INDICATES SHORT MESSAGE FORMAT

Figure 18.7-6. SARP-M Input Message Formats

Table 18.7-1
SARP-M Parameters

Parameters	Values	
Input Frequency	406.025 ± 24 KHz	
Input Signal Strength	-108 to -131 dBm	
Frequency Interference Tolerance	Frequency (MHz)	Maximum Interference Signal Level (dBm)
	1-15	0
	15-375	-20
	375-385	-60
	385-401	-100
	401-411	-145
	411-425	-100
	425-435	-60
	435-1,000	-20
	1,000-10,000	0
Memory Capacity	327,680 bits (2048 short messages or 1820 long messages)	
Processor Capability	90 Messages in Field of View per pass with 95 percent probability.	

(8) DRU 2 OFF:

Removes power from DRU 2.

(9) Read Memory Continuously:

If Relay A or B is ON and memory is ON, messages stored in the memory are read and transmitted, LIFO, starting with the latest message and ending with the oldest message, and to repeat this process continuously until another Memory command is received. Transmission of playback (stored) messages is interrupted (at the end of a message) when a new message is received, and resumed when the new message has been transmitted. If the memory is filled and new messages are received during the playback, the last message received will be stored as the latest (most recent) message in memory. Memory content is not affected by reading in this mode and resets the status of the other Read modes to OFF.

(10) Read Memory Single Shot:

Exactly the same as Read Memory Continuously, except that playback is terminated at the end of one cycle.

(11) Read/Erase Memory Single Shot:

Exactly the same as Read Memory Single Shot, except that the content of the memory is erased (replaced by zero words) by the reading.

(12) Memory OFF:

Removes power from memory and resets status of all read modes to OFF.

(13) Memory ON:

If Relay A or B is on, powers memory and activates Write mode. With Write mode activated when a message is -received, it is simultaneously transmitted and stored in the memory_, except that these actions are delayed until transmission of any partially transmitted message is complete. If the memory is already filled, the new message will overwrite the oldest message in the memory. It also resets the status of all Read modes to -OFF.

(14) Read Memory Continuously:

If Relay A or B is ON, and memory is ON, causes messages stored in the memory to be read and transmitted, LIFO, starting with the latest message and ending with the oldest message, and to repeat this process continuously until another Memory command is received. Transmission of playback (stored) messages is interrupted (at the end of a message) when a new message is received, and resumed when the new message has been transmitted_ If the memory is filled and new messages are received during the playback, the last message received will be stored as the latest (most recent) message in memory. Memory content is not affected by reading in this mode.

(15) Read Memory Single Shot:

Exactly the same as Read Memory Continuously, except that playback is terminated at the end of one cycle.

(16) Read/Erase Memory Single Shot:

Exactly the same as Read Memory Single Shot, except that the content of the memory is erased (replaced by zero words) by the reading.

18.7.6.7 Digital B Telemetry

Digital B Telemetry is “one bit” telemetry which describes “off-on” instrument status. This telemetry is shown in Table 18.7-12.

Table 18.7-I 1
SARP-M Commands

Command Name (2)	MNEMONIC	CIU/CXU Buffer Bit	Type (1)	Reset Logic (4) State
SARP-M ON-A	SRPAN	A88/4	Pulse Discrete	F
SARP-M OFF-A	SRPAF	A88/7	Pulse Discrete	F
SARP-M ON-B	SRPBN	ACO/5	Pulse Discrete	F
SARP-M OFF-B	SRPBF	ACO/6	Pulse Discrete	F
DRU1 ON	SDU1N	ACO/7	Pulse Discrete	F
DRU1 OFF	SDU1F	ACO/8	Pulse Discrete	F
DRU2 ON	SDU2N	ACO/9	Pulse Discrete	F
DRU2 OFF	SDU2F	ACO/10	Pulse Discrete	F
Read Memory Continuously	SMRCN	17/6	Pulse Discrete (6)	F
Read Memory	SMRSS	17/8	Pulse Discrete (6)	F
Read/Erase Memory	SMRER	17/7	Pulse Discrete (6)	F
Memory OFF	SARMF	17/4	Pulse Discrete (6)	F
Memory ON	SARMN	17/3	Pulse Discrete (6)	F

1. These circuits do not use hysteresis latching.
2. DRU = Data Recovery Unit
3. See Figure 9 for the SARP-M Command Receiver Circuit.
4. State assumed when CIU or CXU is reset at power turn On.
   T = True = 0 Volt; F = False = + 5 V.
5. Standard interface (GIIS Figure 12)
6. CXU Buffer

Table 18.7-12
Digital B Telemetry

No.	Telemetry Point Name	State* (1) Logic "0"	Logic "1"	Minor Frame	Channel #	Word 12 Bit #
1	SARP-M Relay A Status	**ON**	OFF	2	258	1
2	SARP-M Relay B Status	**ON**	OFF	2	282	2
3	DRU 1	**ON**	OFF	2	306	3
4	DRU 2	**ON**	OFF	2	330	4
5	SARP-M Time Code (MSB)	—	—	8	264	1
6	Memory ON/OFF	**ON**	OFF	6	334	4
7	Read Continuously	**ON**	OFF	22	326	3
8	Read Single Shot	**ON**	OFF	14	342	4
9	Read/Erase Single Shot	ON	OFF	23	351	4

*Logic "0" or "High Voltage" state (5 ± 0.7 V) is "ON."
(1) All Digital **"B"** telemetry reads logic "1" when the SARP-M is OFF.

18.7.6.8 SARP-M Analog Telemetry

SARP-M analog telemetry is shown in Table 18.7-13 and defined by the following list:

- RU Temperature
  - Function: To monitor Receiving Unit temperature from -10°C to 50°C
- USO Temperature
  - Function: To monitor USO temperature from 0°C to + 100°C.
- USO Thermal Regulation Voltage
  - Function: To monitor USO regulation voltage which controls oven temperature

Table 18.7-13
SARP-M Analog Telemetry

No.	Telemetry Point Name	Tip Sub Corn	Tip Minor Frame	Channel #
1	RU — Temperature	A16A	0,160	384
2	USO — Temperature	A16A	80,240	464
3	USO Thermal Regulation	A16A	50,210	434
4	RGR Receiver	A16A	11,171	395
5	SPU — Temperature	A16A	58,218	442
6	PCU — Temperature	A16A	66,226	450
7	Converter — Temperature	A16A	74,234	458
8	Converter Voltage + 5 V	A16A	91,251	475
9	Converter Voltage + 12 V	A16A	98,258	482
10	Converter Voltage -12 V	A16A	122,282	506

- RGR Receiver
  - Function: To monitor the RGR receiver voltage.
- SPU Temperature
  - Function: To monitor the Box 2 (processing unit) temperature from -10°C to + 50°C.
- PCU Temperature
  - Function: To monitor the Box 1 (power unit) temperature from -10°C to + 50°C.
- Converter Temperature
  - Function: To monitor the power converter temperature.

- Converter Voltage + 5 V
  - Function: To monitor the + 5 volts SARP-M powerline voltage.
- Converter Voltage + 12 V
  - Function: To monitor the + 12 V SARP-M powerline voltage.
- Converter Voltage -12 V
  - Function: To monitor the -12 volt SARP-M powerline voltage.

18.8 SOLAR BACKSCATTER ULTRAVIOLET SPECTRAL RADIOMETER (SBUV/2)

18.8.1 FUNCTIONAL DESCRIPTION

18.8.1.1 Purpose of Instrument

The purpose of the Solar Backscatter Ultraviolet Spectral Radiometer (SBUV/2) is to map, on a global scale, total ozone concentrations and the vertical distribution of ozone in the Earth's atmosphere. Since the required information cannot be measured directly, the SBUV/2 instrument is designed to provide data, on an operational basis, from which the distribution of ozone can be determined on the ground.

Two separate measurements are made to collect the data. The ratio of the two sets of data is of primary importance. First, the SBUV/2 measures the spectral radiance of the solar ultraviolet radiation backscattered from the Earth; and second, the direct solar spectral irradiance is measured. Both measurements are made in the spectral range from 160 to 400 nanometers (nm). Such data will further the understanding of:

- The structure and dynamics of the ozone layer
- The photochemical process in the atmosphere and the influence of trace constituents on the ozone layer
- The long-term solar flux changes in the ultraviolet

18.8.1.2 General Description

The SBUV/2 is a nonspatial scanning, spectrally scanning instrument designed to measure scene radiance and solar spectral n-radiance in the spectral range from 160 nm to 400 nm to permit the calculation of total ozone in the Earth's atmosphere. The instrument operates in four distinct modes. In the first mode, called the Discrete Mode, the instrument sequentially measures the scene radiance or the solar spectral ix-radiance in 12 discrete spectral bands. In the second mode, called the Sweep Mode, the spectral bandpass sweeps from 400 nm to 160 nm in a quasicontinuous manner (actually a rapid series of small, discrete steps). In this mode, radiometric measurements are made by electronic sampling of the output signal, while the grating moves. Either the scene spectral radiance or solar spectral irradiance is measured in this mode; in the latter case the diffuser must be deployed. In the third mode, called the Wavelength Calibration Mode, the instrument operates as in the Discrete Mode, but stops at 12 preselected wavelength positions bracketing one of the strong emission lines of the onboard calibration lamp. In the fourth mode, called the Position Mode, the spectral scan mechanism moves to and remains at a preselected position upon receipt of the command. This mode is used primarily for instrument testing; but, with the use of the instrument diffuser, both scene radiance and solar h-radiance can be measured.

The SBUV/2 instrument (Figure 18.8-1) consists of two separate modules: a Sensor Module (SM), and an Electronics and Logic Module (ELM). The SM is mounted to the Earth-facing surface of the Advanced Tiros-N (ATN) Equipment Service Module (ESM). The ELM is mounted to the back of the Earth-facing surface within the ESM and connected electrically to the SM via a separate cable assembly. All spacecraft electrical interfaces with the instrument are made through the ELM (Figure 18.8-2).

The SM contains a spectral scanning double monochromator, a cloud cover radiometer, mechanisms, and some electronics; the ELM contains the bulk of the electronics.

The SBUV/2 instrument measures backscattered solar radiation in an 11.3' X 11.3" field of view (FOV) in the nadir direction at 12 discrete, 1.1 nm wide wavelength bands between 252.0 nm and 339.8 nm using a spectral scanning double monochromator. The solar n-radiance is determined at the same 12 wavelength bands by deploying, upon ground command, a diffuser to reflect sunlight into the instrument FOV. The atmospheric radiance measurement relative to the solar n-radiance measurement is the significant data.

The SBUV/2 instrument can also measure the solar irradiance or the atmospheric radiance with a continuous spectral scan from 400 nm to 160 nm in increments of nominally 0.148 nm. These measurements provide data on photochemical processes in the atmosphere and long-term solar flux changes in the ultraviolet.

A separate narrowband filter photometer channel, called the Cloud Cover Radiometer (CCR), continuously measures the Earth's surface brightness at 379 nm, i.e., outside the ozone absorption band. The CCR is located in the same structure as the monochromator, and its FOV is the same size (11.3' X 11.3') as, and is coaligned with, the monochromator's FOV.

18.8.1.3 Data Products

The data system for SBUV/2 consists of circuitry to output all the instrument radiometric, voltage, and temperature monitors and general status information. All of this information is transferred via the spacecraft Tiros Information Processor (TIP) and will be available wherever TIP data are obtained, whenever the SBUV/2 is on. The SBUV/2 data system will utilize TIP digital-A, digital-B, and subcommutated analog channels.

18.8.1.3.1 Digital-A-The SBUV/2 is designed to output all digital instrument data to the TIP digital-A data channels. These data include all radiometric signals, sync words, instrument temperatures, encoder position, and any other information required for utilization of the radiometric data and for monitoring the status and general health of the instrument.

18.8.1.3.2 Digital-B-The digital-B or bilevel telemetry consists of single-bit status monitors used for command verification. The sample rate of each of the 22 alloted bilevel channels will be once every 3.2 sec.

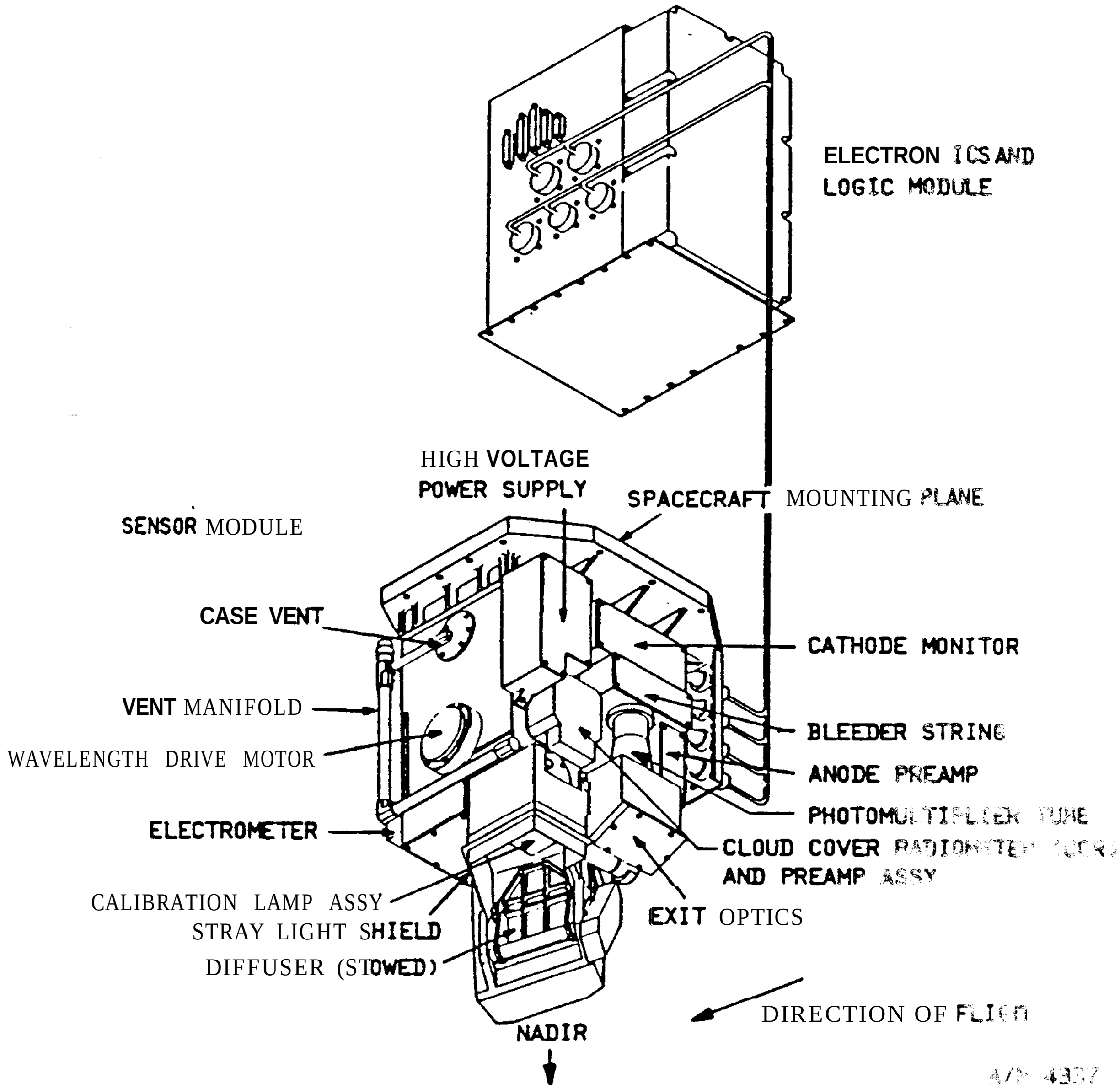


Figure 18.8-1.SBUV/2 Instrument

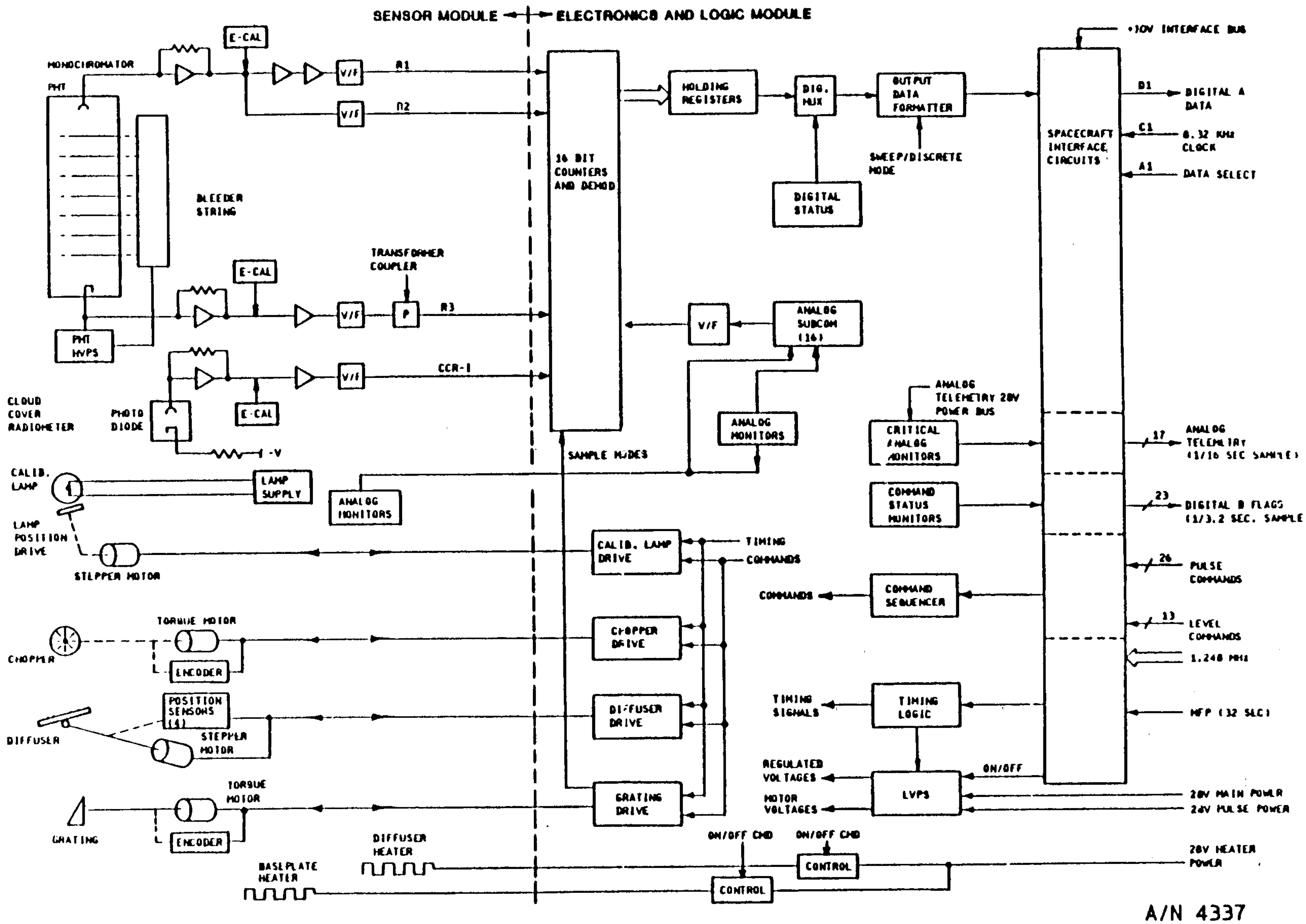


Figure 18.8-2. Block Diagram of SBUV/2 Electrical System

18.8.1.3.3 Subcommutated Analog Telemetry These telemetry channels are intended for instrument use primarily to monitor temperatures. Seventeen analog telemetry circuits are used by the SBUV/2, 15 of which are powered from the instrument dc/dc converter. The spacecraft provides a separate switched +28 V bus to each instrument for monitoring housekeeping temperature when the instrument is off; two SBUV/2 temperature monitors are powered by this bus.

18.8.1.3.4 Data Storage--The SBUV/2 utilizes no onboard data storage.

18.8.2 SYSTEM DESCRIPTION

18.8.2.1 Introduction

The SBUV/2 is functionally similar to the SBW system flown on Nimbus-7. The SBUV/2 incorporates dual Ebert-Fastie monochromators mounted in tandem on a single shaft; this is necessary to meet the stray light rejection requirements. This monochromotor assembly is the heart of the SM. The grating position (spectral bandpass) is provided by an encoder-controlled direct-drive system with direct readout of grating position. The incoming W light passes through a depolarizer and chopper before entering the entrace slit of the monochromator itself. Upon exiting the monochromator, the dispersed energy is directed to the photocathode of a PMT via a transfer optics assembly.

A separate radiometric channel, an atmospheric window channel, lies parallel to the monochromator; the chopper is the only common element. The detector in this case is a vacuum photodiode, and the spectral bandpass is provided by an optical filter. A simplified optical schematic is provided in Figure 18.8-3.

The sensor module also contains a “calibration” lamp assembly which utilizes an Hg Pen-Ray lamp. This lamp is used to spectrally calibrate the monochromator in orbit and to monitor the reflectance of the flight diffuser. The diffuser assembly is provided so that the direct solar irradiance can be measured-a measurement essential for ozone determination. In addition, the SM contains electronics for powering the high voltage supplies, and signal processing of radiometric data. All additional electronics are contained in a separate module, the ELM.

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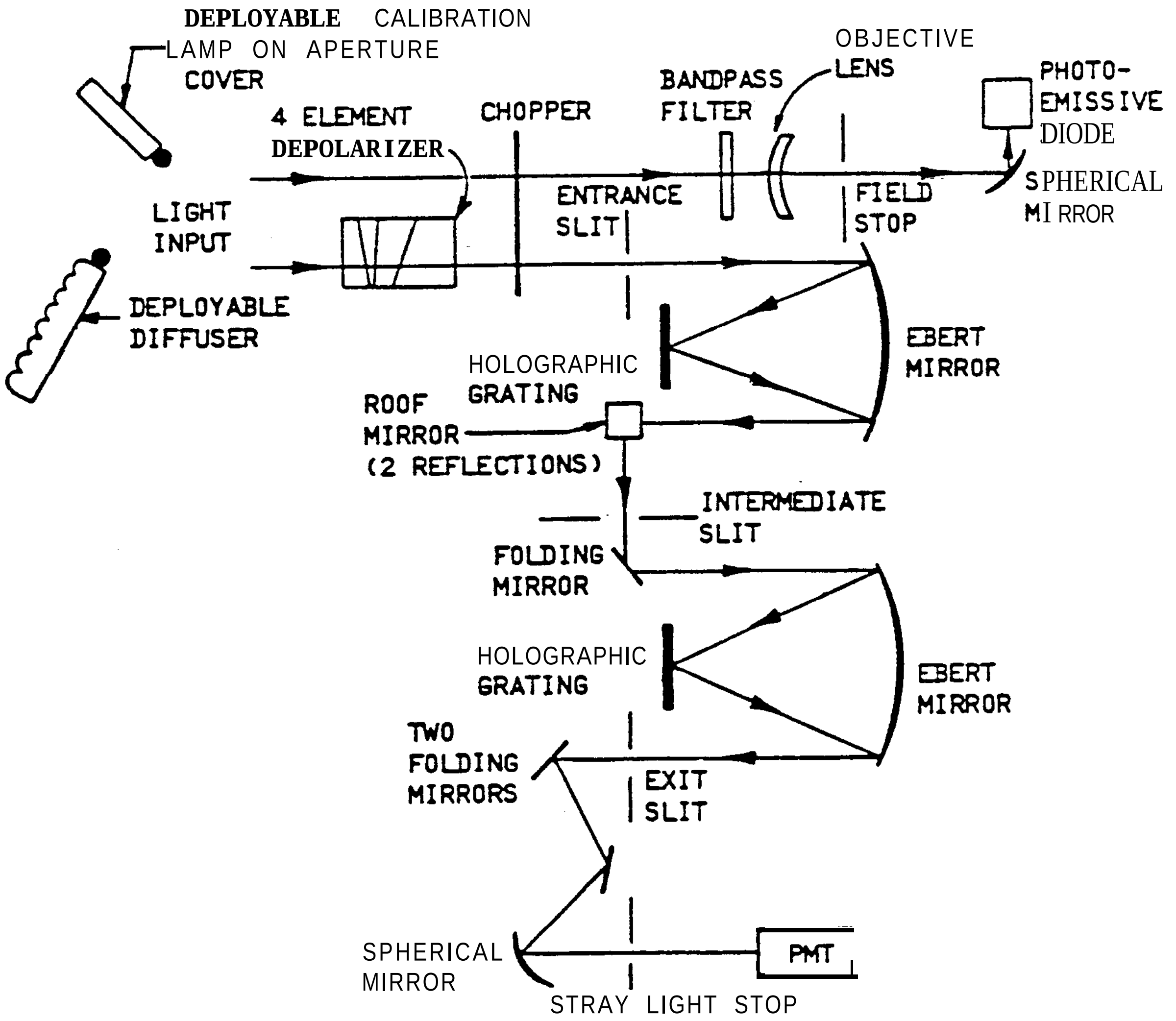
18.8.2.2 System Performance Requirements

The essential features governing the performance requirements are:

1. The instrument must operate over a dynamic range of 10^6.

2. The instrument cannot be radiometrically calibrated in orbit because the Sun is not stable enough, and suitable sources do not exist.

3. The absolute accuracy of the radiance-to-ii-radiance ratio measurement must approach one percent.



A/N 4337

Figure 18.8-3. Simplified Optical Path

4. NBS-supplied sources suitable for instrument calibration have a maximum dynamic range of 40.

Instrument performance requirements are summarized in Tables 18.8-I to 18.8-4 and the following subparagraphs.

18.8.2.2.1 Instantaneous Field of View (IFOV)-The SBUV/2 shall have a half-power IFOV whose size is 11.33 ±0.57 degrees for all spectral bands in the Discrete Mode and the CCR. In addition, the half-power IFOV shall be square to within 0.1 degree, and each channel of the Discrete Mode shall have an IFOV that does not differ from the CCR IFOV by more than 0.1 degree in each of two perpendicular directions.

18.8.2.2.2 Field Uniformity-The relative response, as measured by two mutually perpendicular scans of a point or narrow slit source across the IFOV (one scan perpendicular to and one scan parallel to the entrance slit) shall not vary by more than ±10 percent from the mean, within an angular interval, centered in the IFOV, whose width is 80 percent of the half-power IFOV. The width of the point or narrow slit source shall not exceed 10 percent of the required IFOV. In the case of the CCR the variation within the 80 percent of half-power IFOV shall not exceed ±5 percent.

18.8.2.2.3 Out-of-Field Response-The total system response obtained while the instrument (masked to exclude a central FOV having an angular dimension 10 percent larger than the measured half-power IFOV) views a large, uniform, diffuse source intending an angle at the entrance aperture 10 times the half-power IFOV and whose intensity does not exceed the maximum expected scene radiance, shall not exceed 1 percent of the total system response obtained while the instrument views the same source with the mask removed, at any spectral position within the range 250 nm to 400 nm. In addition, any strong, localized beam of UV energy impinging on the diffuse plate at any position outside the masked out area, with the mask in place, shall not exceed the observed system noise.

18.8.2.2.4 Optical Alignment

18.8.2.2.4.1 Precision-All alignment measurements shall be made with a precision of 0.01 degree or better.

18.8.2.2.4.2 Alignment Requirements-The optical axis of the monochromator and of the CCR shall be aligned parallel to within 0.1 degree. The alignment of the optical axis of the monochromator to the instrument reference shall be 0.1 degree or less, and the alignment of the instrument reference axis to the spacecraft +X axis (nadir) shall be 0.1 degree or less. The optical axis is defined as the direction determined by disecting the angle between the half-power response points determined from two mutually perpendicular FOV scans. This requirement shall hold between each spectral band in the Discrete Mode and the CCR and the instrument reference.

Table 18.8-1 SBUV/2 Spectral Bandpass Requirements

Central Wavelength (nm)	Bandwidth (nm)
Discrete Mode	
339.89 ± 0.05	$1.0 \pm \frac{0.2}{0}$
331.26 ± 0.05	"
317.56 ± 0.05	"
312.57 ± 0.05	"
305.87 ± 0.05	"
301.97 ± 0.05	"
297.59 ± 0.05	"
292.29 ± 0.05	"
287.70 ± 0.05	"
283.10 ± 0.05	"
273.61 ± 0.05	"
252.00 ± 0.05	"
Sweep Mode 160 – 400 ± 0.25	$1.0 \pm \frac{0.2}{0}$
Cloud Cover Radiometer 379 ± 1.0	3.0 ± 0.3

Table 18.8-2 SBUV/2 Dynamic Range Requirements

	Discrete Mode	Sweep Mode	Cloud Cover Radiometer
Maximum Scene Radiance (mW/M^2–sr–Å)	40 (339.8 nm)	53 (400 nm)	40
Minimum Scene Radiance (mW/M^2–sr–Å)	1.2 x 10^{-4*}	1.2 x 10^{-4*}	0.125
Maximum Solar Irradiance (mW/M^2–Å)	120 (339.8 nm)	166 (400 nm)	N/A
Minimum Solar k-radiance (mW/M^2–Å)	3 (252 nm)	0.01 (160 nm)	N/A

Table 18.8-3 SBUV/2 Minimum Signal to Noise

Central Wavelength (nm)	Required S/N (Note 1)		Source Intensity
	Radiance Measurements		Radiance.
	Discrete Mode	Sweep Mode (Note 4)	(mW/M^2-sr-Å)
252.0	35	10	(Note 2)
273.61	100	30	4.98 X 10^{-4}
283.10	200	60	9.78 X 10^{-4}
287.70	260	80	1.30 x 10^{-3}
292.29	400	145	2.39 x 10^{-3}
297.59	4 0 0	210	3.48 x 10^{-3}
301.97	400	230	3.84 X 10^{-3}
305.87	400	400	6.72 X 10^{-3}
312.57	400	400	1.49 x 10^{-2}
317.56	400	400	3.09 x 10^{-2}
331.26	400	400	2.08 x 10^{-1}
339.89	400	400	4.12 X 10-t
CCR	100	---	(Note 3)
	Irradiance Measurements		Irradiance (W/cm^3)
160	---	2	0.26
170	---	50	0.30
180	---	250	0.80
190	---	400	1.60
200	---	400	3.40

Notes:
1. Except for data pertinent to Notes 2, 3, and 4, the required S/N values are not true signal-to-noise ratios. These values are to be defined as peak signal divided by background noise (rms).
2. To be measured while viewing a uniform target whose radinace is 1.20 X 10^{-4} mW/M^2-sr-Å averaged between 25 l nm and 253 nm.
3. To be measured while viewing a uniform target whose radiance is 0.125 mW/M^2-sr-Å averaged between 375 nm and 385 nm.
4. In the sweep mode at the crossover between gain ranges 1 and 2 the maximum required S/N shall not exceed 100 at any specified wavelengths above 292 nm.

Table 18.8-4 Absolute Radiometric Accuracy

Wavelength (nm)	Source	Max. Percent Error of				Max. Absolute Error of Measurement (RSS)
		Source	Source* Transfer	Diffuser (Goniometric)	Other Error	
Spectral B-radiance Calibration (Instrument Diffuser)						
200-250	Mini-Arc	6.0	3.5		1.0	7.02
250	QI	2.6	2.0		1.0	3.43
300	QI	2.1	2.0		1.0	3.07
350	QI	1.7	2.0		1.0	2.81
400	QI	1.5	2.0		1.0	2.69
Spectral Radiance Calibration (Test Diffuser)						
200-250	Mini-Arc	6.0	3.5	2.9	1.0	7.30
250	QI	2.6	2.0	1.0	1.0	3.57
300	QI	2.1	2.0	1.0	1.0	3.23
350	QI	1.7	2.0	1.0	1.0	2.98
400	QI	1.5	2.0	1.0	1.0	2.87

*Includes nongoniometric diffuser errors.

18.8.2.2.5 Out-of-Band 'Response-The total out-of-band response, integrated over all wavelengths outside a spectral region three times the measured bandwidth but centered on the central wavelength (λo), shall not be greater than 1 percent of the response within the total measured bandpass for all spectral bands between 250 nm and 400 run. If N_λ is the scene radiance and S_λ is the instrument transfer function and AA is the measured half-power bandwidth, then:

$$\frac{\int_{-\infty}^{\lambda o-\frac{3\Delta\lambda}{2}} S_\lambda N_\lambda d_\lambda + \int_{\lambda o+\frac{3\Delta\lambda}{2}}^{\infty} S_\lambda N_\lambda d_\lambda}{\int_{\lambda o-\Delta\lambda}^{\lambda o+\Delta\lambda} S_\lambda N_\lambda d_\lambda} \leqslant 0.01$$

To demonstrate compliance with this specification, the total out-of-band response shall be determined by direct measurement or by a combination of measurement and analysis for each band of the Discrete Mode and for the CCR. The source used shall simulate as close as possible the spectral characteristics of the solar n-radiance.

18.8.2.2.6 Spectral Resolution-The SBUV/2 monochromator shall have a spectral resolution capability of 0.2 nm, for the entire slit height, over the spectral range 250 nm to 400 nm. This can be demonstrated by measurement at 253.7 nm and extended by ray trace analysis to the balance of the spectral range.

18.8.2.2.7 Polarization Sensitivity-The sensitivity of the SBUV/2 to linear polarization of the scene, as given by the following equation, shall be no greater than 0.05 for all wavelengths in the range 252.0 nm to 339.8 nm.

$$Ps = \frac{I\,max - I\,min}{Imax+Imin} \leqslant 0.05$$

where I max is the maximum response of the SBUV/2 to a 100 percent linear polarized source, and I min is the minimum response of the SBUV/2 to a 100 percent linear polarized source of the same intensity. The polarization operator of the test equipment used in the measurement of the polarization sensitivity must be independently determined and analytically removed from the system test results.

18.8.2.2.8 System Linearity-The nonlinearity of system response shall not exceed 1 percent of the output signal over the total dynamic range. If the system response to a scene radiance of 'No' is 'Ro,' then system response to a scene radiance of 'nNo' must be nRo ± 0.01 (nRo - Ro); where 1) 'n' is any nonzero positive number, 2) 'No' and 'nNo' must lie within the required or expected dynamic range of the channel (extrema included), and 3) system response shall be the mean of a minimum of 50 samples. In addition, system response shall be independent of instrument orientation in Earth's magnetic field. Compliance with these requirements shall be demonstrated by measurement in air only.

18.8.2.2.9 Radiometric Stability and Repeatability

18.8.2.2.9.1 Short-Term Stability-The radiometric response of the instrument shall meet the following stability requirements. The corrected mean response of the instrument shall not differ by more than 1 percent from a previous or subsequent response measurement made while viewing the same source operating at equal intensity but separated in time by at least 24 hours for each wavelength in the Discrete Mode. The mean response is to be determined from at least 50 successive data samples taken with the wavelength drive stopped at each Discrete Mode position. These instrument data are to be corrected for changes in instrument temperature and other responsedependent parameters, if any, before comparisons are made.

18.8.2.2.9.2 Long-Term Stability-It is desired that the change in radiometric response, as defined in the previous paragraph, shall not change by more than 3 percent over a period of 6 months. Because of the impracticability of demonstrating compliance by actualmeasurement before instrument delivery, compliance can be demonstrated by an estimate of long-term stability based on analysis. This analysis must use measured instrument rates of change as well as vendorsupplied subsystem test data.

18.8.2.2.9.3 Wavelength Accuracy and Precision-All wavelength measurements for both the Discrete Mode and Sweep Mode shall be made with an absolute accuracy given by the tolerance on'the defined wavelength in Table 18.9-l. The required measurement precision during ground calibration of SBUV/2 shall be ±0.005 nm or better.

18.8.2.2.10 Instrument Calibration

18.8.2.2.10.1 In-Flight Measurement of Detector Gain-The SBUV/2 shall provide for in-flight measurement of changes in gain of the detector(s), including the preamplifier stage. The measurements shall be sensitive enough to determine a gain change of 0.5 percent or less in the spectral range 300 nm to 340 nm. Averaging of 100 measurements is permissible.

18.8.2.2.10.2 In-Flight Wavelength Calibration-The SBUV/2 shall provide the means of in-flight wavelength calibration. The onboard calibration shall be sensitive enough to detect a 0.1-nm shift in the indicated wavelength with a measurement precision of 0.01 nm.

18.8.2.2.10.3 Preflight Calibration: Ratio of Radiance to Irradiance Accuracy-The ratio of the radiance calibration to u-radiance calibration at the same wavelength shall be determined to an accuracy of 2.35 percent in the spectral range 200 nm to 250 nm and to an accuracy of 1.53 percent at 250 nm; 1.57 percent at 300 nm and 1.82 percent in the spectral range 340 nm to 400 nm. The ratio is to be determined from radiance and G-radiance measurements made with a minimum time separation; i.e., at each Discrete Mode wavelength, the spectral drive is to be stopped and both measurements made before continuing. During the time of ratio measurement, the instrument response shall not vary by more than 0.5 percent.

18.8.2.2.10.4 Inflight Diffuser Calibration—The contractor shall demonstrate by direct test that the system provided to monitor the diffuser performance is sensitive enough and has the stability required to detect a one percent change in the diffuser relative spectral reflectance in orbit, with a precision of 0.5 percent, over the spectral range 185 nm to 405 nm. This can be demonstrated on a test to test basis or by using averages of up to eight automated data sequences which approximates the monthly orbital data collection in this mode.

18.8.2.3 Operational Phases and Modes

The SBUV/2 is a nonspatial scanning, spectrally-scanning instrument. It operates in several distinct phases and modes which can be selected by command. There are three operational phases, four monochromator modes, four scene modes, and a diffuser decontamination mode. The operational phases are:

- Launch and Orbital Acquisition Phase-The monochromator aperture is covered by a two position calibration lamp assembly; the diffuser is stowed, and the power is off.

- Mission Phase-This is the normal operating mode. Selected combinations of four monochromator modes and four scene modes are possible.

- Standby Phase-The baseplate heater can be turned on if needed. However, analysis shows that this will not be required.

The four monochromator modes are:

- Discrete Mode-The gratings are stepped to each of the 12 discrete wavelength positions and dwells at each position for 1.25 seconds. This is repeated until another mode is selected.

- Sweep Mode-The gratings are continuously moved to sweep the wavelength range of 400 nm to 160 nm. This is repeated until another mode is selected.

- Wavelength Calibration Mode-The gratings are stepped to 12 discrete positions around the 253.7-nm line or any other preselected line from an onboard mercury calibration source. This is repeated until another mode is selected.

- Position Mode-The gratings are moved to, and stopped at, the position commanded. The gratings will stay in this position until commanded to another position or into another mode.

The four scene modes are:

- Earth View Mode

- Sun View Mode

- Wavelength Calibration Mode

- Diffuser Check Mode

All data are obtained during the Mission Phase. Figure 18.8-4 shows the various mode combinations that can be used during the Mission Phase. The primary science data are collected when viewing the Earth and the Sun. The Cloud Cover Radiometer (CCR) views the same scene as the monochromator, sampling incoming energy at 379 nm. Independent of the monochromator mode, the CCR integrates the scene for 1 second every 2-second period.

The Launch Phase, Diffuser Check Sequence, Diffuser Decontamination Mode, and the four scene modes are chosen by selecting one of four positions for the diffuser and one of two positions for the wavelength calibration lamp. The wavelength calibration lamp is a mercury lamp housed within the deployable door over the entrance apertures. Figure 18.8-5 shows the combinations and the monochromator operating modes (grating drive mechanism) that accompany them. The positions of the diffuser and the calibration lamp and the operation of the grating drive define the operating mode.

In the Launch Phase, the diffuser is stowed in an enclosure, protected from outgassing products, debris, and combustion products from the orbit-adjust thrusters. The calibration lamp assembly serves as a contamination cover over the entrance aperture for both the monochromator and the CCR.

In the Earth View Mode, the diffuser remains stowed and the lamp assembly is deployed to the open position. The monochromator operates in either the Discrete or Sweep Mode.

In the Sun View Mode, the diffuser is deployed to 28" below the instrument Y-Z plane. Sunlight is reflected into the entrance aperture during a portion of each orbit.

The frequency of the allowed Sun-viewing opportunities and their durations depends upon the orbit geometry. For the nominal mission, the spacecraft is in a Sun-synchronous, near-polar orbit with the ascending node between 1400 and 1800 local mean time. Orbit period is approximately 102 minutes. The spacecraft +X axis is always vertical downward; the spacecraft +Y axis points back along the velocity track; and the +Z axis is along the positive normal to the orbit. The Sun lies within 68" of the +Z axis. In spacecraft coordinates, the Sun line cones about the Z-axis at an angle γ, once every orbit. Figure 18.9-6 shows its path in direction space. The diffuser is on the bottom of the spacecraft in a location where parts of the spacecraft shadow it whenever the Sun is above the Y-Z plane or to the -Y side of the X-Z plane, or within 3" of the X-Z plane.

When the Sun is less than 62° from the +X axis, the Earth shadows the whole spacecraft. Thus, the diffuser is sunlit only when the Sun is in the shaded region of Figure 18.8-6.

The diffuser must be tilted so it sees no earthshine, putting its normal within 28° of the -X axis. So, as the Sun approaches the limb of the Earth (at 62" from the +X axis), the diffuser is illuminated at an extremely large incidence angle.

Whenever γ is greater than 3°, the Sun shines on the diffuser once every orbit (i.e., once every 102 minutes). Figure 18.8-7 shows how long during each orbit the diffuser is illuminated with the Sun between 75 and 90 degrees from the X-axis. Part of the time shown may include shadowing from spacecraft antennas.

SCENE MODES	OBSERVED SOURCE	VIEWING MODES	MONOCHROMATOR MODES: SWEEP MODE*	MONOCHROMATOR MODES: DISCRETE MODE*	MONOCHROMATOR MODES: WAVELENGTH CALIBRATION MODE*	MONOCHROMATOR MODES: MONO-CHROMATOR POSITION MODE	CCR MODES	DIFFUSER DECONTAM-INATION MODE
SCENE MODES	EARTH	RADIANCE MODE	✓	✓		✓	✓	INSTRUMENT APERTURE PROTECTED, DIFFUSER HEATER ON
SCENE MODES	SUN	IRRADIANCE MODE	✓	✓		✓	✓	INSTRUMENT APERTURE PROTECTED, DIFFUSER HEATER ON
SCENE MODES	DIRECT VIEW OF Hg LAMP	DIFFUSER CHECK SEQUENCE	✓		✓	✓		INSTRUMENT APERTURE PROTECTED, DIFFUSER HEATER ON
SCENE MODES	DIFFUSER ILLUMINATED BY Hg LAMP	DIFFUSER CHECK SEQUENCE	✓		✓ (OPTIONAL)	✓		INSTRUMENT APERTURE PROTECTED, DIFFUSER HEATER ON
	CYCLE TIME REMARKS		192 SEC	32 SEC	32 SEC	BY COMMAND	CONT. SAMPLES AT 2 Hz	BY COMMAND

*PORTIONS OF THESE MODES PROVIDE FOR ELECTRONIC CALIBRATION OF THE MONOCHROMATOR SPECTROMETERS

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Figure 18.8-4. Instrument Operating Modes (Mission Phase)

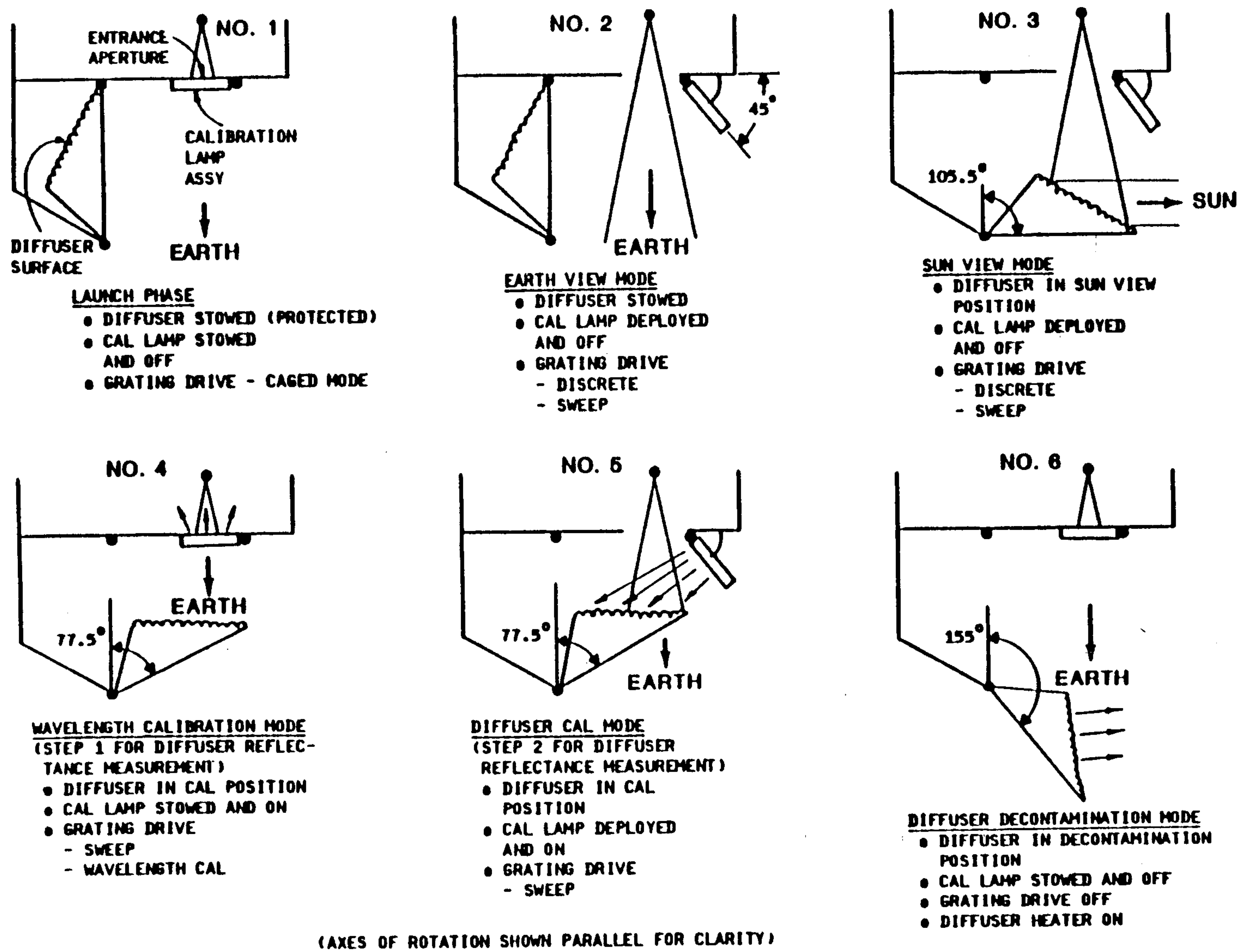

Figure 18.8-5. Diffuser and Calibration Lamp Positions

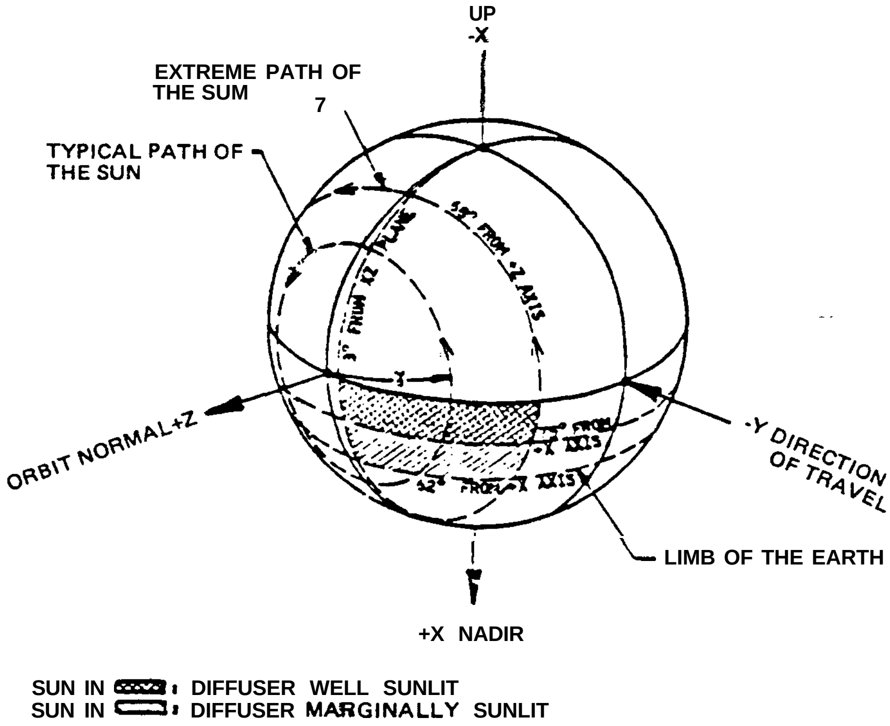

Figure 18.8-6. Geometry for Solar Irradiance Measurement
(In **Direction** Space)

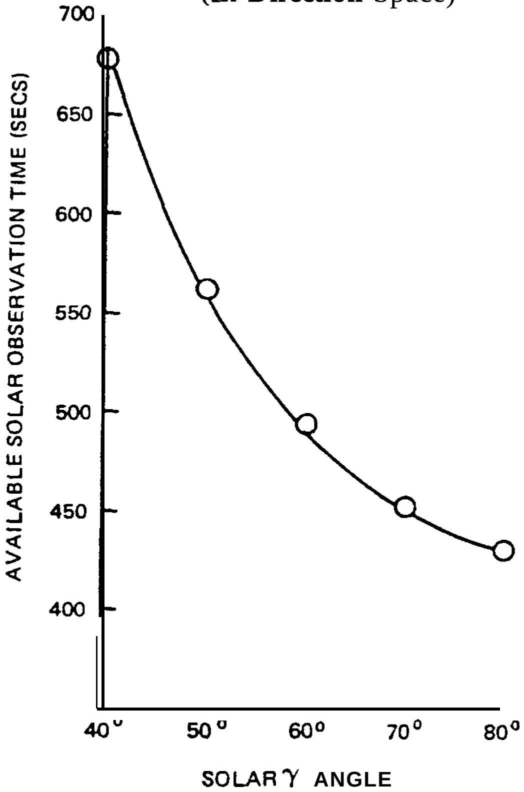

Figure 18.8-7. Time Available for Solar h-radiance Measurement

During the Sun View Mode, the monochromator is operated in either the Discrete or the Sweep Mode.

During the Wavelength Calibration Mode (see Figure 18.8-5), the diffuser can be stowed or can be directly in front of the instrument aperture, and the calibration lamp assembly is closed covering both apertures. In the Sweep Mode, the monochromator scans over the mercury lines at 184.0, 253.7, 302.2, 313.2, 365.0, and 404.7 nm. In the Wavelength Calibration Mode, the monochromator can be commanded to sequence through 12 discrete wavelengths around any-desired line from the mercury source.

In the Diffuser Check Mode, the monochromator views the diffuser which is directly in front of the instrument and aperture and is illuminated by the wavelength calibration lamp. The monochromator scans the same line as in the Wavelength Calibration Mode, or it can operate in the sweep mode. The ratios of the two sets of data (the lamp directly and the lamp reflected from the diffuser) provide the check of diffuser spectral reflectivity. These two measurements are completed within 7 minutes.

In the Diffuser Decontamination Mode, both instrument apertures (the monochromator and the CCR) are covered by the Calibration Lamp Assembly (aperture door). The diffuser is pointed away from the instrument and the 5 W heater is turned on, heating the diffuser to approximately 70°C.

The monochromator has four distinct modes as shown in Figure 18.8-4.

- Discrete Mode
- Sweep Mode
- Wavelength Calibration Mode
- Position Mode

The sequencing for each monochromator mode is controlled from either a fixed, ground-programmable memory (FIX system) or from a random access memory programmable by command (FLEX System). The desired memory is selected by command.

Each monochromator mode defines a unique wavelength sequence and a data sampling sequence. At the end of each mode sequence (except the Position Mode), the preamplifiers are switched out and up to ten precision voltage levels are inserted into the electronics for calibration of the analog electronics and the voltage-to-frequency converters.

Beginning at the first major frame following a Discrete Mode command, the gratings sequentially move to and dwell at the 12 discrete wavelengths. Figure 18.8-8 shows the wavelength-versus-time profile. The signal at each wavelength is integrated for 1.25 seconds. An additional 0.75 second is allowed for moving to and settling at the next wavelength. Thus, the 12 discrete wavelengths

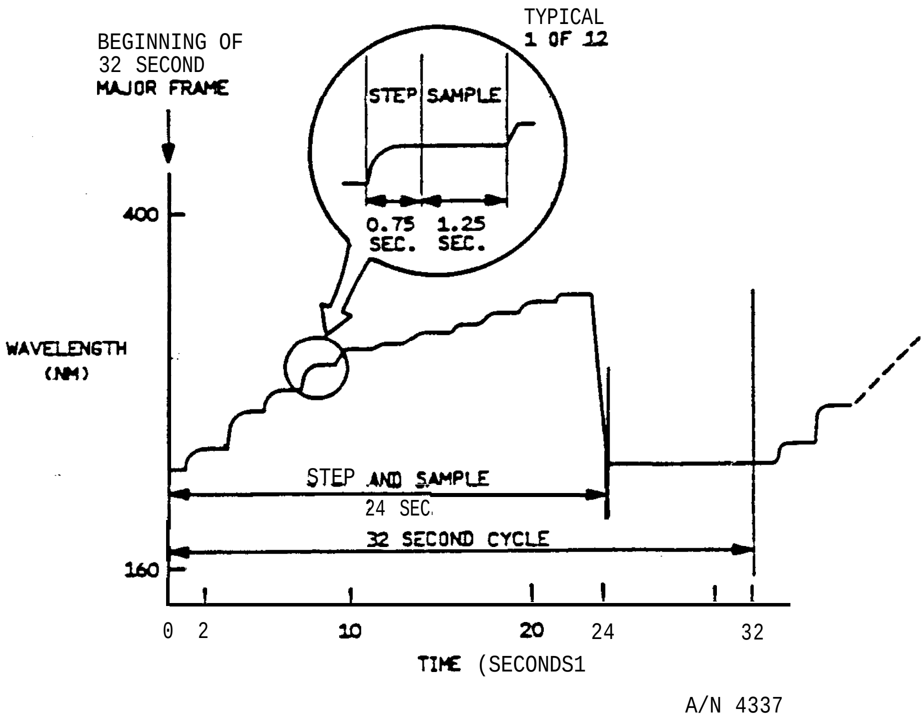

Figure 18.8-8. Discrete Mode Timing

are covered in 24 seconds. This allows 8 seconds for returning to the first discrete wavelength, electronic calibration, and waiting for the start of the next major frame. The 12 discrete wavelengths specified in Table 18.8-1 are stored in the FIX system. Any 12 wavelengths can be commanded into the FLEX system.

Beginning at the first major frame following receipt of a Sweep Mode command, the wavelength range from 407 nm to 160 nm is scanned in nominally 0.074-nm steps. Figure 18.8-9 shows the wavelength-versus-time profile. The monochromator signal is integrated for 0.1 second resulting in nominally 0.148 nm sample increments. Therefore, 1680 spectral measurements are made between 407 nm and 160 nm. This takes 168 seconds. The grating drive then retraces to 407 nm and waits for the start of the next major frame. Thus, the total cycle time for the Sweep Mode is 192 seconds. Electronic calibration takes place during the time period between 168 seconds and 192 seconds. The starting position (407 nm) is stored in the FIX system. Any starting position can be commanded into the FLEX system. During operation, either starting point will be followed by the 1680 spectral measurements.

The Wavelength Calibration Mode is functionally very similar to the Discrete Mode. Beginning at a major frame, the grating moves to and dwells at 12 separate wavelengths, each separated by nominally 0.296 nm, around any single desired line source. At each wavelength, data are integrated for 1.25 seconds. Figure 18.810 shows the timing for this mode and an example of the resulting

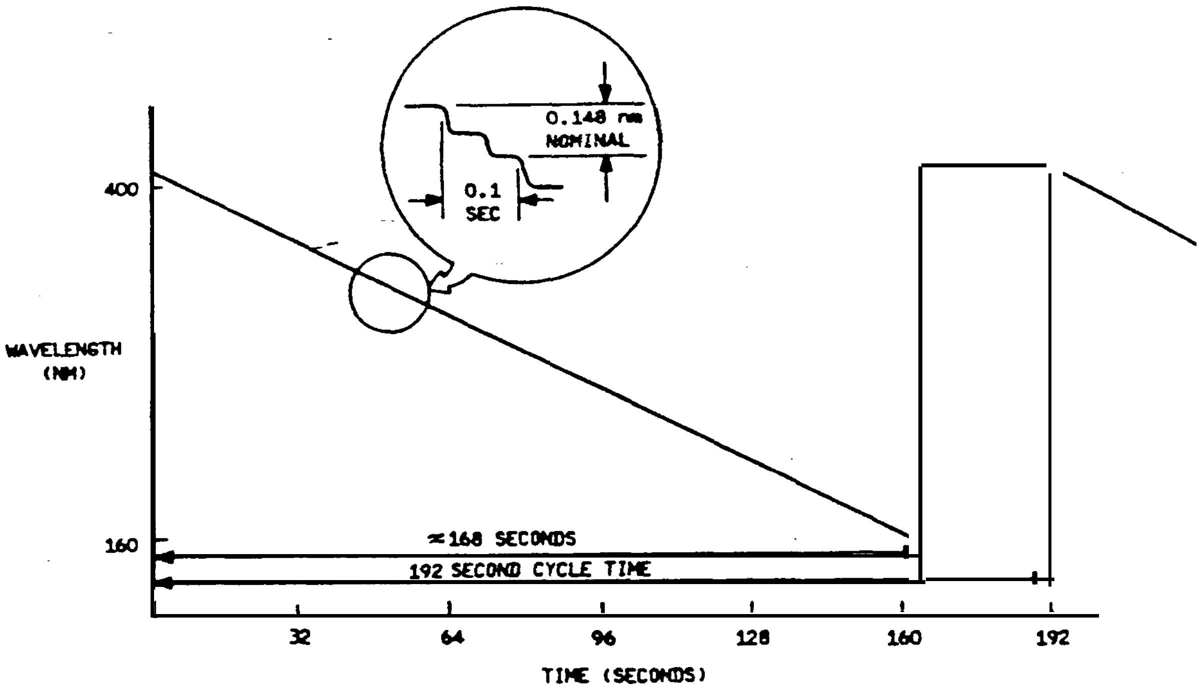

Figure 18.8-9. Sweep Mode Timing

data. The FIX system will store the starting wavelength for the 253.7-nm mercury line and the remaining 11 wavelengths are achieved through logic. The FLEX system can be programmed to start sequencing at any wavelength.

Upon receipt of a Position Mode command and at the start of the next major frame, the grating goes to the grating shaft position location in memory, The FIX system will contain a preset position. However, any position can be commanded into the FLEX system. The grating will remain at this position until a new position is loaded into the FLEX system or until receipt of a new mode command. In the Position Mode, data are integrated for 1.25 seconds during every 2-second period as in the Discrete Mode. There is no ECAL during the Position Mode.

18.8.2.4 Radiometric Input

Both the monochromator and the cloud cover radiometer are designed to view sources or targets that are larger than their 11.3' X 11.3' fields of view (such as the Earth), and to measure the average radiant power within the field of view. When viewing the Sun, which is smaller than the instrument's field of view, the onboard instrument diffuser takes the rays from the one-half-degree Sun and provides a diffuse source that overfills the instrument field of view.

The range of radiant power that the monochromator and the cloud cover radiometer measure is illustrated in Figure 18.8-11. Solar irradiance values have been converted to radiance levels at the

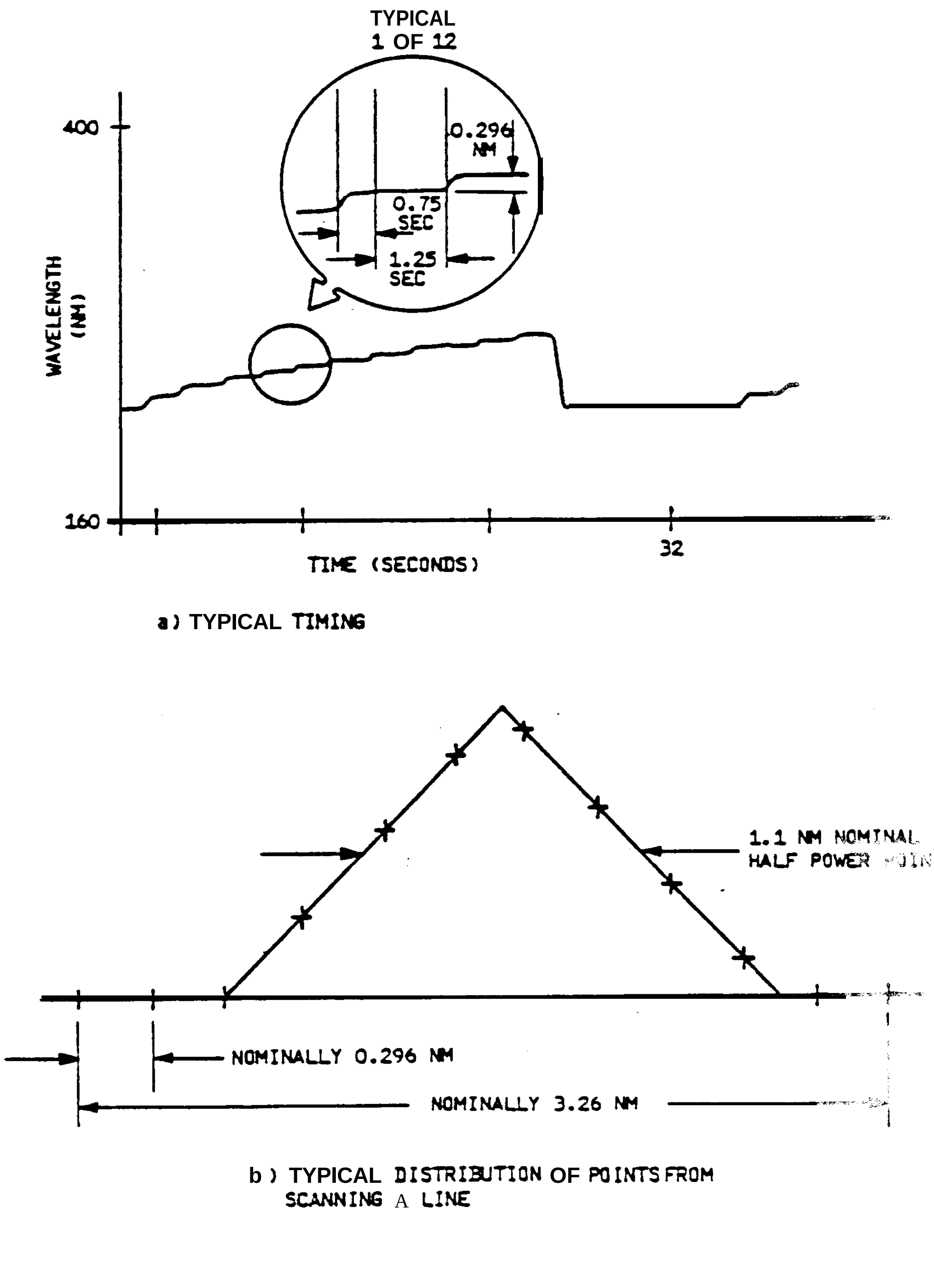

Figure 18.8-10. Wavelength Calibration Mode Timing

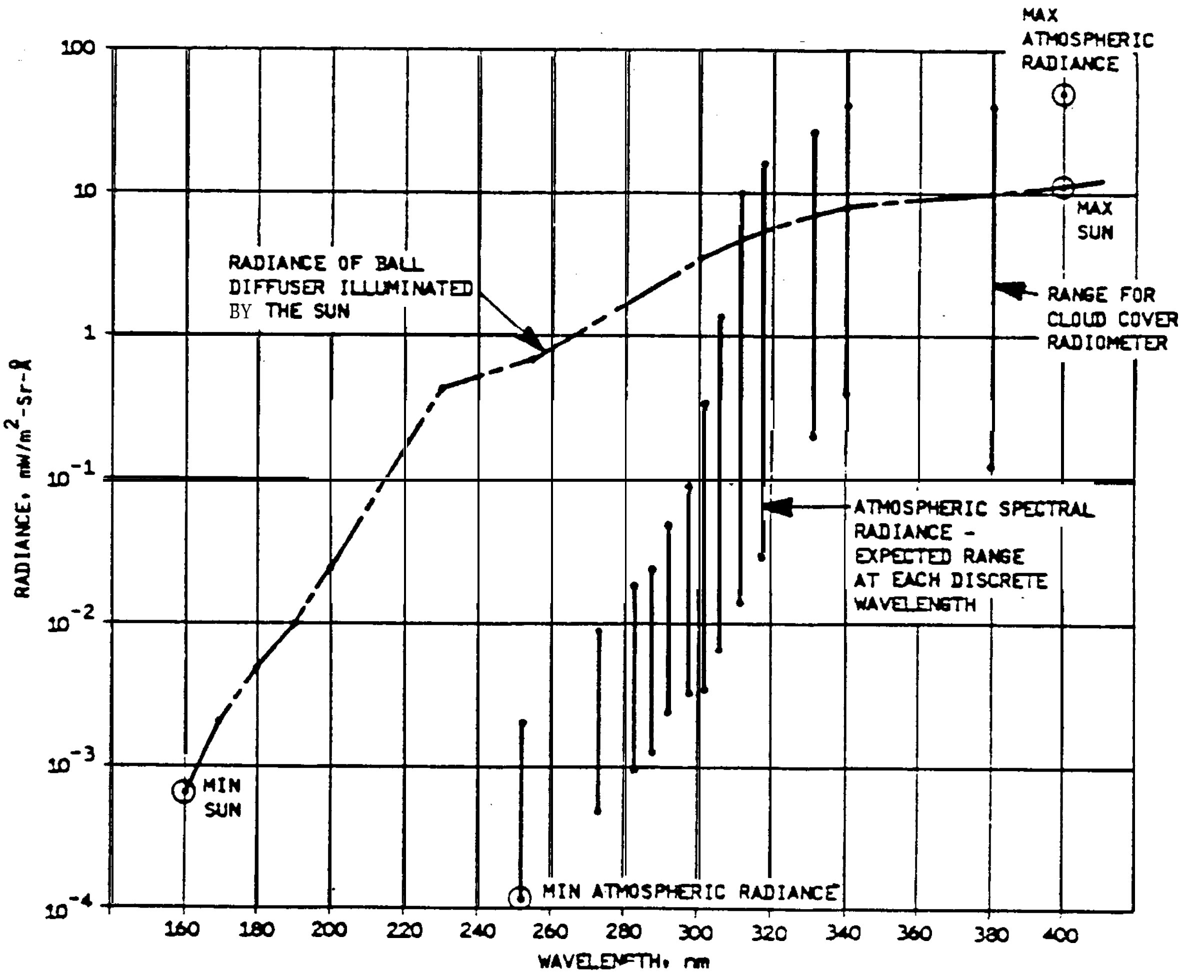

Figure 18.8-11. Range of Radiance Power to be Measured

onboard diffuser by using an average diffuser transfer factor or efficiency of 0.068 mW/m^2-sr-Å per mW/m^2-A.

The efficiency or throughput of the monochromator is strongly dependent upon the wavelength, especially below 180 nm where the transmissions of the depolarizer and photomultiplier tube faceplate substantially drop off. Figure 18.8-12 shows the expected range of photomultiplier anode currents for the monochromator. The maximum radiance values will typically be encountered in the equatorial regions and the minimum radiances over the polar regions. Figure 18.8 12 also show the range of cathode currents for the cloud cover radiometer.

In addition to accommodating a wide range of radiance levels, the depolarizer makes the SBUV/2 instrument relatively insensitive to different levels of polarization. The instrument also contains a precise wavelength drive system.

18.8.2.5 Sensor Module Description

Figure 18.8-13 highlights the optical elements to aid in following the light paths through the Sensor Module. Figure 18.8-14 is a functional block diagram of the Sensor Module.

Photons reach the entrance aperture from several possible sources. First, with the diffuser stowed and the aperture cover open, Earth radiation directly enters the aperture. Second, with the diffuser deployed to the Sun view position, solar radiation is reflected into the aperture. Third, for in-flight calibration, light from an onboard mercury lamp, located in the aperture cover, can be directed straight into the aperture or reflected from the diffuser when the diffuser is in the calibration position.

The light passes through a four-element cultured quartz depolarizer and is chopped before reaching the entrance slit of the monochromator. Light for the cloud cover radiometer does not pass through the depolarizer but is chopped immediately. The chopper consists of a five-bladed wheel that is driven in phase-lock at four revolutions per second (20 Hz chopping frequency) by a three-phase brushless dc motor.

Energy at the entrance slit of the monochromator undergoes two reflections from each of the Ebert mirrors, three reflections at the intermediate mirrors, and diffraction at each of [illegible] ings before leaving the monochromator at the exit slit. After three more reflections [illegible] optics, the energy passes through the quartz faceplate of the photomultiplier tube (PMT) and [illegible] the photocathode where it is converted to current.

In the PMT, the current is amplified by the factor of 500 between the cathode and the anode. The currents at the cathode and the anode are sensed with transimpedance preamplifiers. To cover the large range of signals, two gain stages are used at the anode and one gain stage at the cathode. The analog signals are converted to digital frequencies in the voltage-to-frequency converters. These digital signals are routed to the Electronics and Logic Module where digital synchronous demodulation and integration occurs in up/down counters.

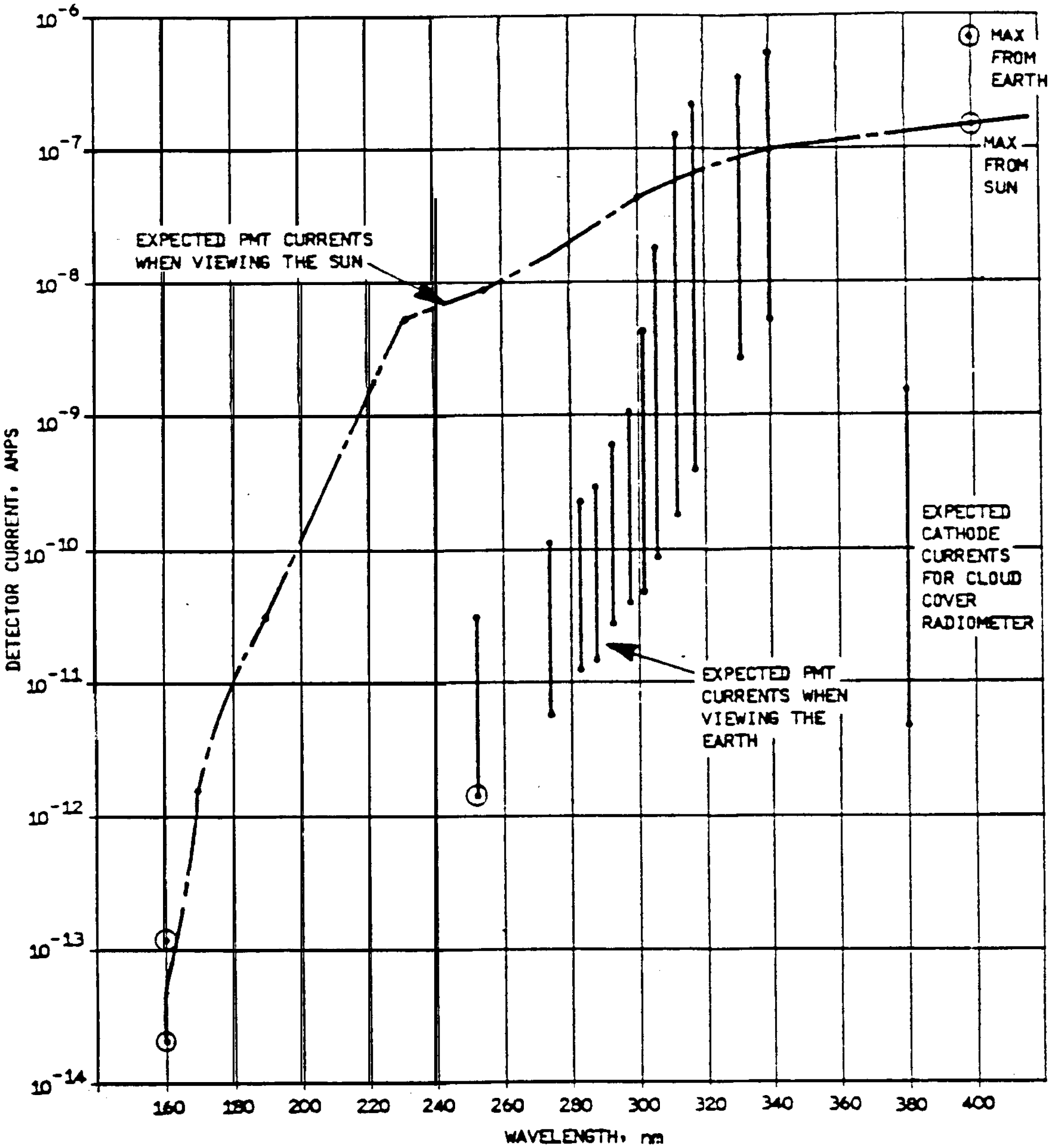

Figure 18.8-12. Range of Detector Currents

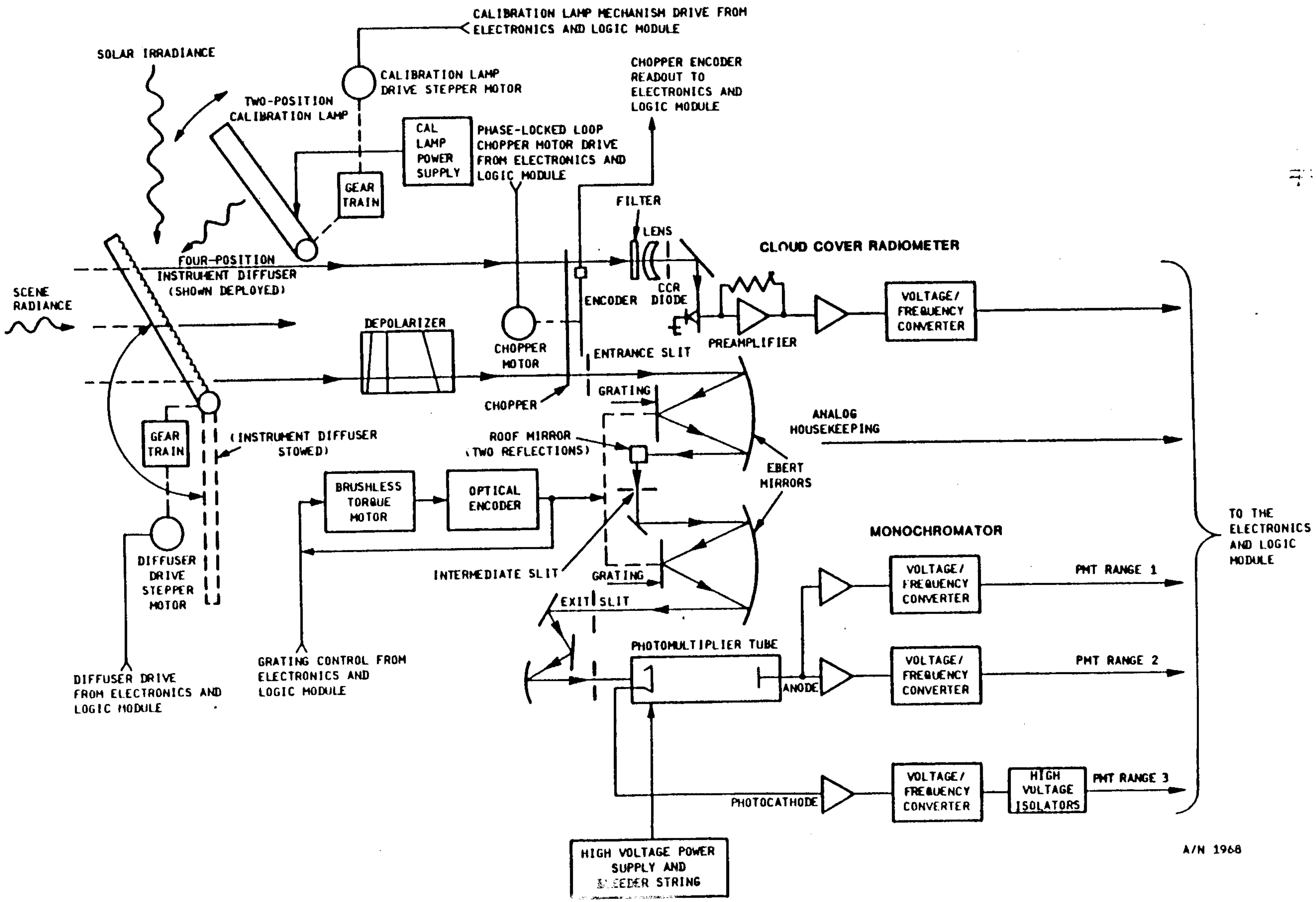

Figure 18.8-13 Functional Diagram of the Sensor Module

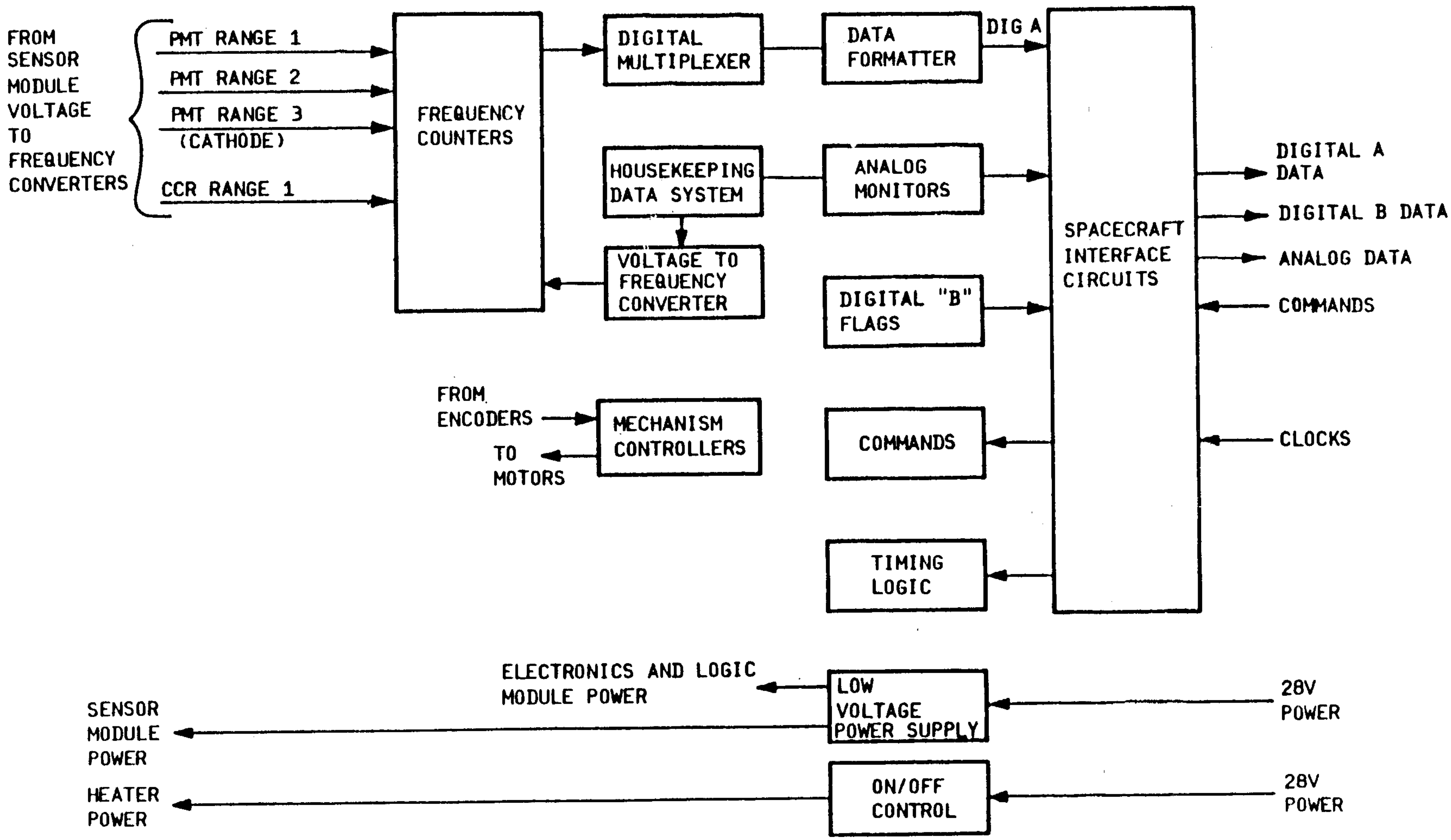

Figure 18.8-14. Functional Block Diagram Electronics and Logic Module

All of the cathode circu y through the voltage-to-frequency converters is floating at the negative high voltage potential of the cathode. Input and output signals pass through high-voltage transformer isolators.

In addition to serving as the high signal (low gain) range for the monochromator signals, the cathode current monitor is also used to measure the PMT gain at the anode. This is done on the ground by taking the ratio of the cathode and anode signals where the ranges overlap.

The angular position of the gratings determines the center wavelength of the nominal 1.1 nm bandpass of the monochromator. The grating position is controlled in a closed loop servo system using a brushless dc torque motor and an optical encoder. Electronics located in the Electronics and Logic Module provide the grating control and sequencing.

The cloud cover radiometer (CCR) consists of a lens, a 3-nm-wide filter centered at 379 nm, a folding mirror, a photoemissive diode, and a preamplifier: The diode converts the incident phot ns to a current which is converted to a voltage in the preamplifier. In the electrometer, the preamplifier output is amplified and passed through a voltage-to-frequency converter. In a manner similar to the monochromator channel, the signal is then digitally and synchronously demodulated and integrated in the Electronics and Logic Module.

18.8.2.6 Electronics and Logic Module

The Electronics and Logic Module (ELM) consists of 11 printed circuit boards which plug into a mother board plus the Low Voltage Power Supply (LVPS). Figure 18.8-14 is a functional block diagram of the total Electronics and Logic Module.

The Electronics and Logic Module is a single-point electrical interface between the spacecraft and the Sensor Module. All inputs and outputs to the spacecraft except power (Dig' . . . igital Commands, Analog, Clocks, and Timing) come into the spacecraft interface circuit board. After being preconditioned in this board, the clock, timing and commands are routed to timing and command boards as applicable. The digital multiplexer/formatter takes digital data from Sensor Module and digital status data from the ELM. It then formats it and gates it to the interface which sends it to the Tiros Information Processor (TIP) in the spacecraft. The tim ates all of the timing and clock signals, such as the chopper drive reference clock, demodulation integration clocks, and stepper motor rate clocks.

The low-voltage power supply accepts input power directly from the spacecraft. It provides analog and digital circuit voltages, motor drive voltages, and preconditioned inputs to the voltage and calibration lamp power supplies in the Sensor Module. It filters the +28 V na. d the +28 V pulse load bus before it is converted. Post regulators are on some outputs

18.8.2.7 Detailed Description of Major Subassemblies

18.8.2.7.1 Grating Drive Mechanism-The grating drive mechanism is a subassembly of the monochromator. Partial disassembly of the motor is required for removal from the monochromator, but the gratings, bearing support system and encoder/readout assembly can be removed as a total subassembly. General characteristics are listed in Table 18.8-5 and a block diagram of the grating drive electronics is given in Figure 18.8-15. The gratings are mounted to a shaft which is bearing-supported at each end. The shaft is driven by a limited angle torque motor directly attached to one end of the grating support shaft. An optical encoder is attached to the opposite end of the support shaft for positional control. The grating pivot shaft bearing system consists of a single deep groove bearing adjacent to the motor and a preloaded duplex bearing pair adjacent to the encoder disc.

- Motor. The motor is a limited angle torque motor with ±15° drive capability.

- Encoder. The optical encoder consists of a 2^{14} disc with four primary read stations and four redundant stations. Coupled with the encoder electronics, the encoder provides 2^{16} resolution with 2^{19} repeatability.

Table 18.8-5 Grating Drive Characteristics

Temperature :	
Operating	0°C to 30°C
Nonoperating	-10°C to +4°C
Angular Momentum:	0.0014 nms (maximum instantaneous)
Bearing Quality:	ABEC-7
Weight:	8.0 pounds measured including gratings and frames
Cycle Time:	
Sweep Mode:	192 seconds
Discrete Mode :	32 seconds
Grating Step:	19.78 arc-second
Step-to-Step Accuracy:	±4.95 arc-second
Grating Step Repeatability:	± 1.5 arc-second
Maximum Jitter At Each Step:	±0.5 arc-second
Shaft Angle Readout Resolution:	19.78 arc-second

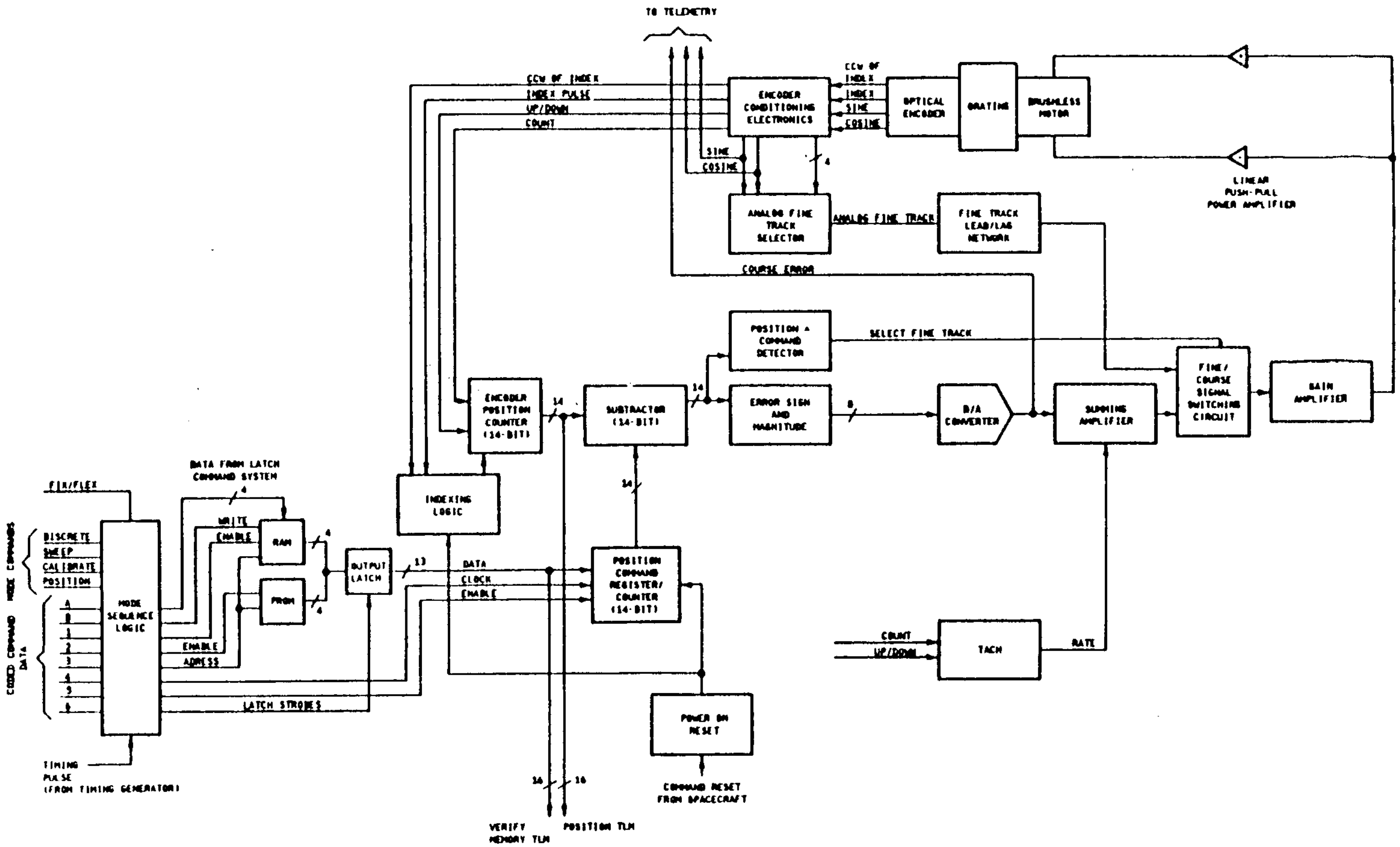

Figure 18.8-15. Block Diagram of Grating Drive Electronics

18.8.2.7.2 Photomultiplier Tube (PMT) Assembly-The Photomultiplier Tube Assembly (Figure 18.8-16) consists of a spherical focusing mirror which images the exit slit onto the PMT, aperture mask (scatter stop), PMT, shielding, preamplifiers, high voltage power supply, and appropriate electronics and housings.

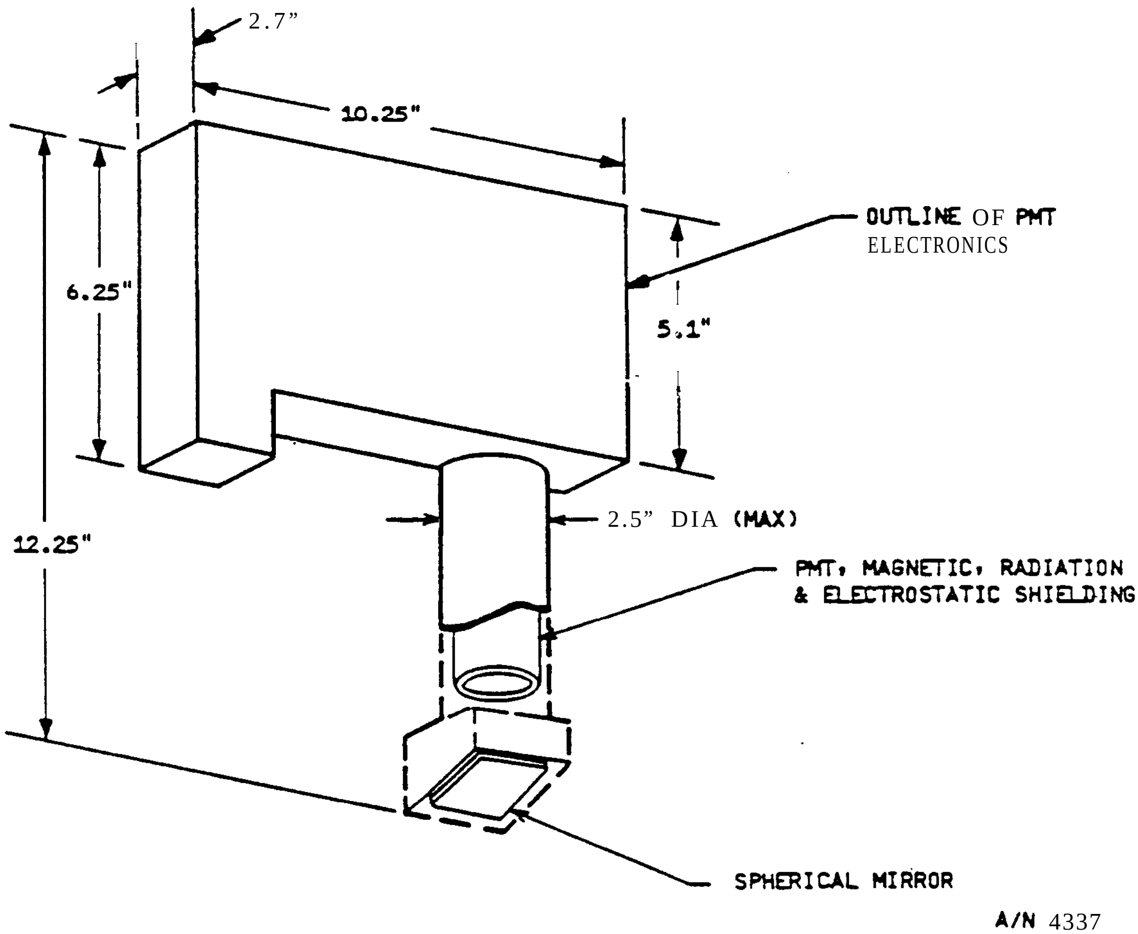

Figure 18.8-16. Photomultiplier Tube Assembly

18.8.2.7.2.1 Photomultiplier Tube-The PMT photocathode is a high quantum efficiency bialkali on a quartz faceplate to provide a high signal over the 160 to 400 nm range. The five dynodes provide a gain of 500.

18.8.2.7.2.2 PMT Electronics-The PMT electronics consist of four electronics boxes containing all of the circuits directly interfacing with the PMT:

- Anode preamplifier
- Bleeder string
- Cathode current monitor preamplifier and electrometer circuitry through the voltage-to-frequency converter

- High-voltage power supply including the float ¸ low-voltage supplies for the cathode current monitor

These circuits are illustrated in Figure 18.8-17. The PMT electronics are located -directly next to and at the rear of the PMT.

Characteristics for the circuits are **as follows**:

- Direct-coupled, transimpedance, FET-input preamplifier
- 10-V fullscale output
- 4.32 X 10^8 ohm feedback resistor
- ⩾300 Hz bandwidth
- Nonlinearity 0.1 percent max. full scale
- Doubled-shielded with inner shield at signal ground and outer shield at chassis ground

Bleeder String

- Passive bleeder string for all dynodes
- 100 A bleeder string current

Cathode Monitor

- Direct-coupled, transimpedance, FET-input preamplifier
  - 1 O-V full-scale output
  - 4.32 X 10^8 ohm feedback resistor
  - 2300 Hz bandwidth
- IO-volt full-scale output at 2 X 10^{-9} A input
- Analog nonlinearity ⩾0.1 percent of full scale
- Analog gain stability better than 1 percent per 5°C
- Four-level electronic calibration
- VFC peak output frequency 122 kHz at 10 Vdc input
- VFC nonlinearity ⩾0.1 percent of full scale
- Double-shielded cathode circuitry with inner shield at -HV and the outer shield at chassis ground

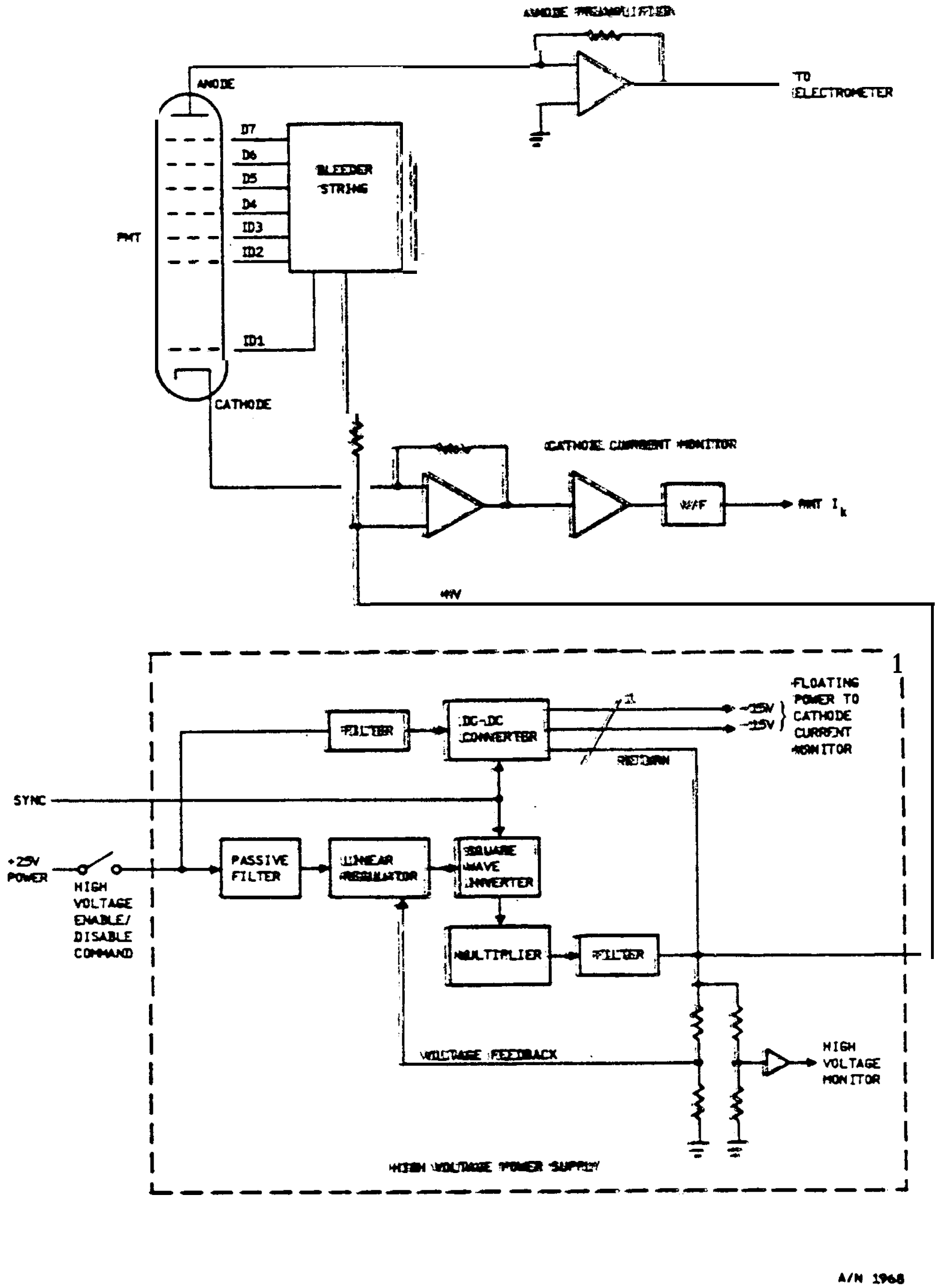

Figure 18.8-17. Block Diagram of the PMT Electronics

- High voltage isolators to couple signals in and out of cathode circuitry

- Response time -300 kHz per msec mm.

18.8.2.7.3 Cloud Cover Radiometer (CCR)-The Cloud Cover Radiometer (CCR) is built as a separate module to simplify fabrication and alignment. This separable assembly consists of a photo-emissive diode, field stop, lens, interference bandpass filter, folding mirror, and preamplifier. Se;: Figure 18.8-18.

Light from the scene goes through the chopper before it gets to the CCR. At the CCR, the light goes through a bandpass filter, a singlet objective lens, and a field stop. A spherical folding mirror then turns the beam 90” and images the light on the detector, which is a vacuum photodiode.

The field stop sets the size of the CCR field of view. The folding mirror images the aperture stop (which is the chopper) on the detector, permitting a smaller detector size and minimizing the field-sensitivity variations that could be caused by a nonuniform detector.

The entire CCR is mounted in a block at the side of the entrance slit of the monochromator so that both the CCR and the monochromator can use the same chopper wheel. Co-pointi:rg is set bv machined shims at the mounting bosses of the CCR block.

18.8.2.7.3.1 Photodiode-The photoemissive diode is smaller to the ITT Diode F4096 The diode has a semitransparent bialkali photocathode of approximately 13 mm diameter. This diode operates at low voltage (10 V) and easily meets the dynamic range of 320: 1. The signal-to-noi-c ratio at minimum signal is about a factor of two higher than the required 100: 1.

18.8.2.7.3.2 CCR Preamplifier-The anode current passes through a transimpedance preamplifier similar to the PMT preamplifiers but located at the rear of the detector in a shielded enclosure, The output then goes to the electrometer to a single fixed range voltage-to-frequency converter. Preamplifier characteristics are:

- Direct-coupled, transimpedance, FET-input preamplifier

- Full-scale current: 2.4 X 10^9 A

- 4.32 X 10^8 ohm feedback resistor

- ⩾300 Hz bandwidth

- Doubleshielded with inner shield at signal ground and outer shield at chassis ground

18.8.2.7.4 Electrometer Assembly-This assembly consists of postamplifiers and voltage-to-frequency converters for two PMT anode ranges and for the CCR range. A temperature sensor is routed to the Electronics and Logic Module for digital conversion,

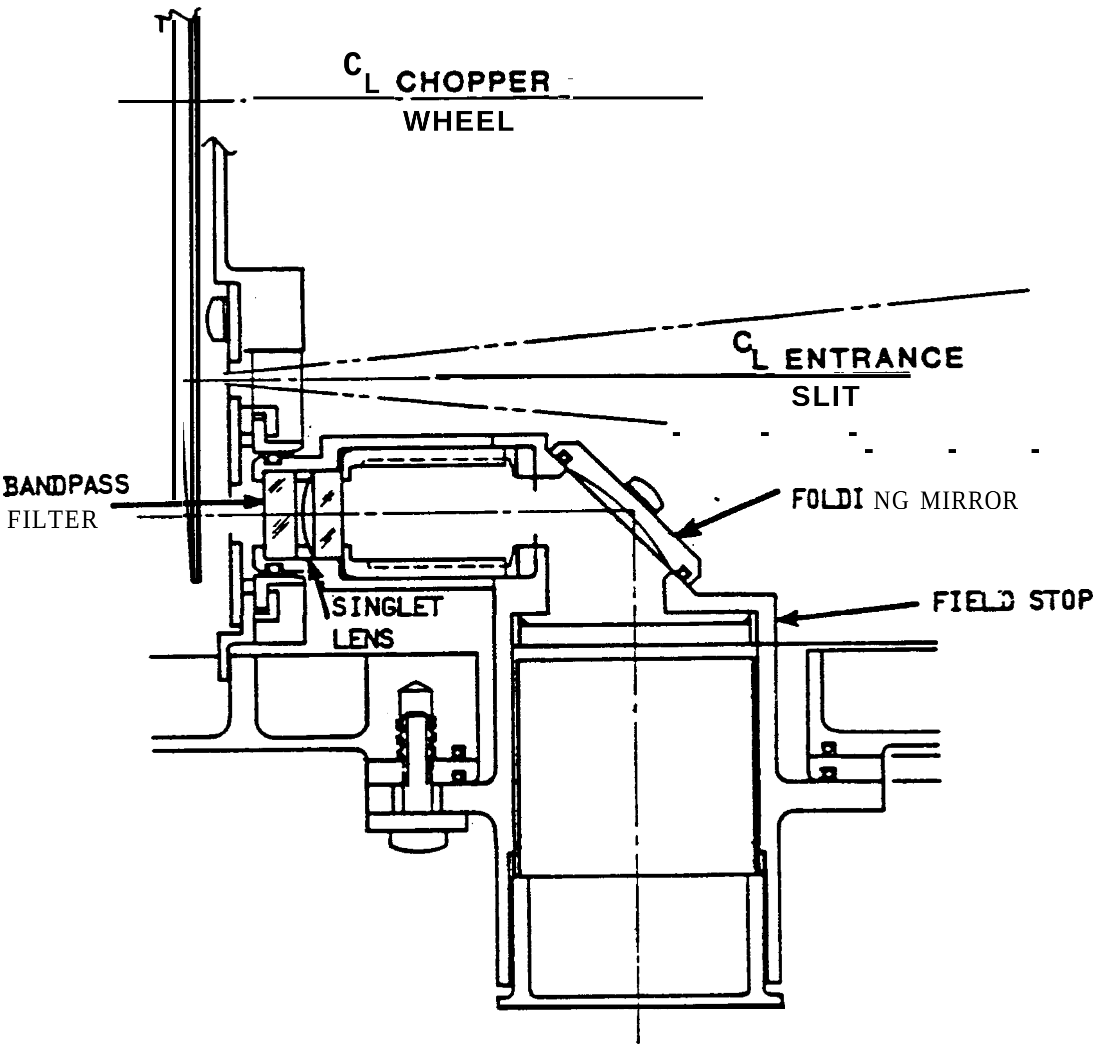

Figure 18.8-18. Cloud Cover Radiometer

Figure 18.8-19 shows the functional block diagram for the electrometer which includes an electrical calibration generator (E-Cal), housekeeping monitors, and power distribution. Each electrometer signal is amplified and then converted to a frequency that is porportional to its amplitude. The frequency is then routed to the ELM for digital processing. The full scale ranges are:

Monochromator Range 1: **0** to 10^{-10} A average anode current

Monochromator Range 2: 10^{-10} to 10^{-8} **A average** anode current

CCR Range 1: 2.4 nA (average) full scale

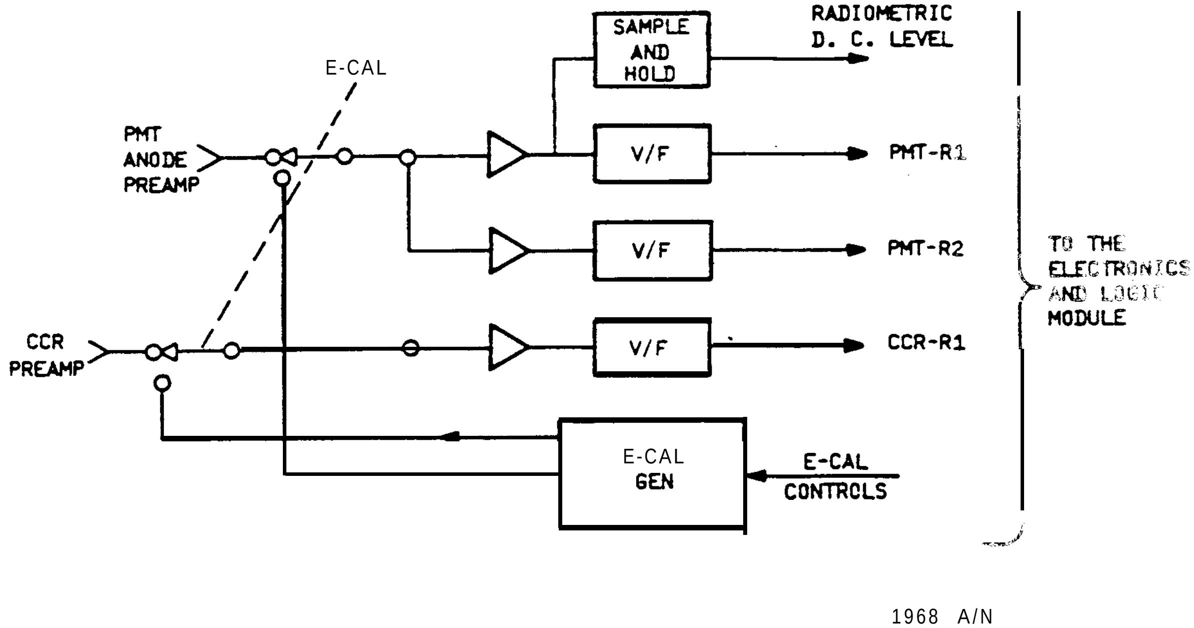

Figure 18.8-19. Block Diagram of the Electrometer Assembly

A summary of the electrometer characteristics is listed in Table 18.8-6.

The electrical calibration system provides automatic monitoring of both PMT and CCR electrometer channel gains. The system operates by switching in ten precision E-Cal charges chopped at 20 Hz immediately after the preamplifiers, as shown in Figure 18.8-19 All detector background is eliminated from the calibration. Calibration is performed during, [illegible] grating. The E-Cal levels are designed to provide four points on each electrometer range.

18.8.2.7.5 Chopper Assembly-The chopper assembly is an, independent subassembly spider mounted to the slit bulkhead. This assembly chops the incoming radiation to both monochromator slit and the CCR. It consists of a brushless, three-phase, dc torque motor, a drive [illegible] chopper, and an encoder. The encoder has both a velocity track and a phase track for the phase locked loop control, and it has three tracks for motor commutation.

Table 18.8-6 Electrometer Characteristics

Package Size:	1.06 H X 7.50 W X 8.25 L in
Package Weight:	2.50 pounds measured
Power:	0.6 W nominal orbital average
Analog Gain Error:	1% per 5°C
Analog Nonlinearity:	0.1% of full scale; 0” to 30°C
Short Circuit Protection:	All outputs
Channel Crosstalk:	<1/2 bit
A/D (V/F) Nonlinearity:	0.1% of full scale
A/D (V/F) Accuracy:	0.04% of full scale at 25°C; 0.1% of full scale 0 to 70°C
E-Cal Levels:	10 Automatic

The chopping rate is 20 Hz and is accomplished by five apertures in a wheel rotating at 240 rpm. The chopping edges of the apertures are held within a 0.005-inch tolerance band. The wheel diameter (limited by interference with the exit optics housing) is 5.067 inches maximum. Figure 18.9-20 shows exposed slit areas versus time for one chopping cycle of the monochromator slit.

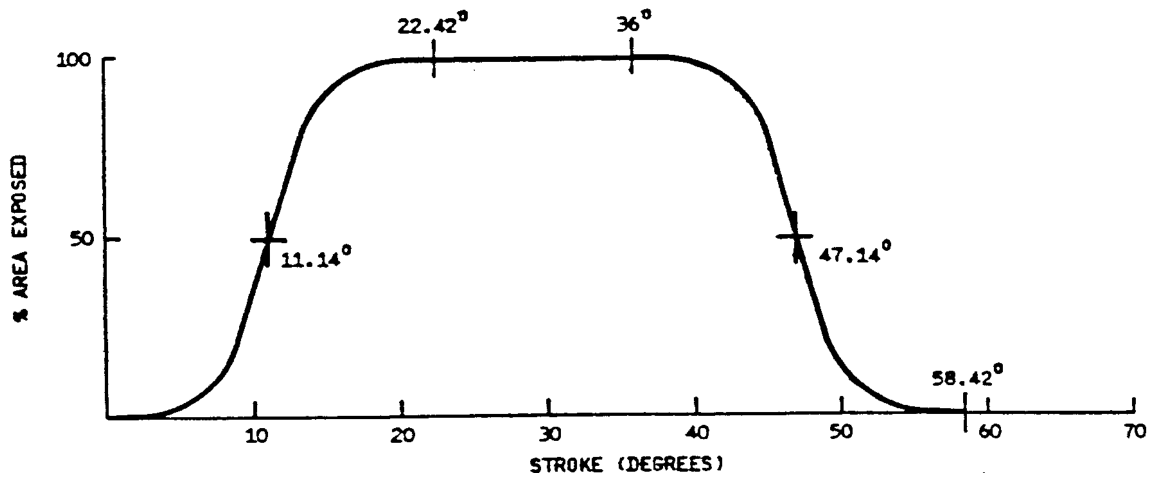

Figure 18.8-20. Chopper Waveform Characteristics

The wheel is driven by a three-phase brushless dc torque motor with velocity control and commutation provided by an optical encoder. The encoder provides the phase reference pulse, and the chopper wheel is adjusted with respect to it. Redundant pickups are provided. Figure 18.8-21 shows the cross section and dimensional extremes of the subassembly. Table 18.8-7 lists the characteristics of the chopper assembly. The chopper drive requirements and characteristics are provided in Table 18.8-8, and the block diagram of the chopper drive electronics is provided in Figure 18.8-22.

18.8.2.7.6 Diffuser Assembly-To measure the solar irradiance, a diffuser is deployed beneath the instrument so that the instrument views sunlight rather than Earth radiance. The original diffuser design consisted of a planar array of 125 small, reflective spherical balls mounted on a plate. However, because of development problems with the ball-type diffuser, it was replaced with a ground aluminum plate overcoated with vacuum deposited aluminum.

In the solar irradiance measurement, the diffuser is deployed so the plate normal is 28” from the zenith-nadir line (i.e., the plate is tilted 28” from the spacecraft Y-Z plane). The plane of the diffuser is thus tangent to Earth’s limb, eliminating earthshine from the Sun measurements.

Because the brightness of the diffuser plate varies as the cosine of the angle of incidence of the sunlight, the goniometric response of each instrument is carefully calibrated.

The diffuser is mounted on a signal-axis tilt mechanism with four discrete positions: Stow, Degradation Check, Sun Viewing, and Decontamination. A simple stepper motor deployment mechanism moves the diffuser to each of the four positions. In Stow position, the plate is tucked against a shallow enclosure where the diffuser surface is protected during launch and ordinary (Earth-look) instrument operation. The working surface of the diffuser is protected from contaminant condensation and solar ultraviolet, which could polymerize any contaminants already present. In Degradation Check position, the plate is perpendicular to the zenith-nadir axis, illuminated by the in-flight reference source, and viewed by the radiometer. In Sun Viewing position, the plate normal makes 28” with the radiometer axes and the Sun measurements are made. The diffuser is further extended to a fourth position for decontamination. The diffuser is heated to 300 K minimum, 373 K maximum to drive off contaminants.

The diffuser is mechanically positioned in any one of the four positions by rotation about a hinge axis. Each position is sensed by optical readout using four LED’s and four phototransistors. The four positions are tabulated in Table 18.8-9. Total travel is 140° minimum.

The hinge line is parallel to the spacecraft Y-Z plane, and the normal to the hinge line in the Y-Z plane makes an angle of 34” with the +Z axis. The drive motor is a 45” permanent magnet stepper motor.

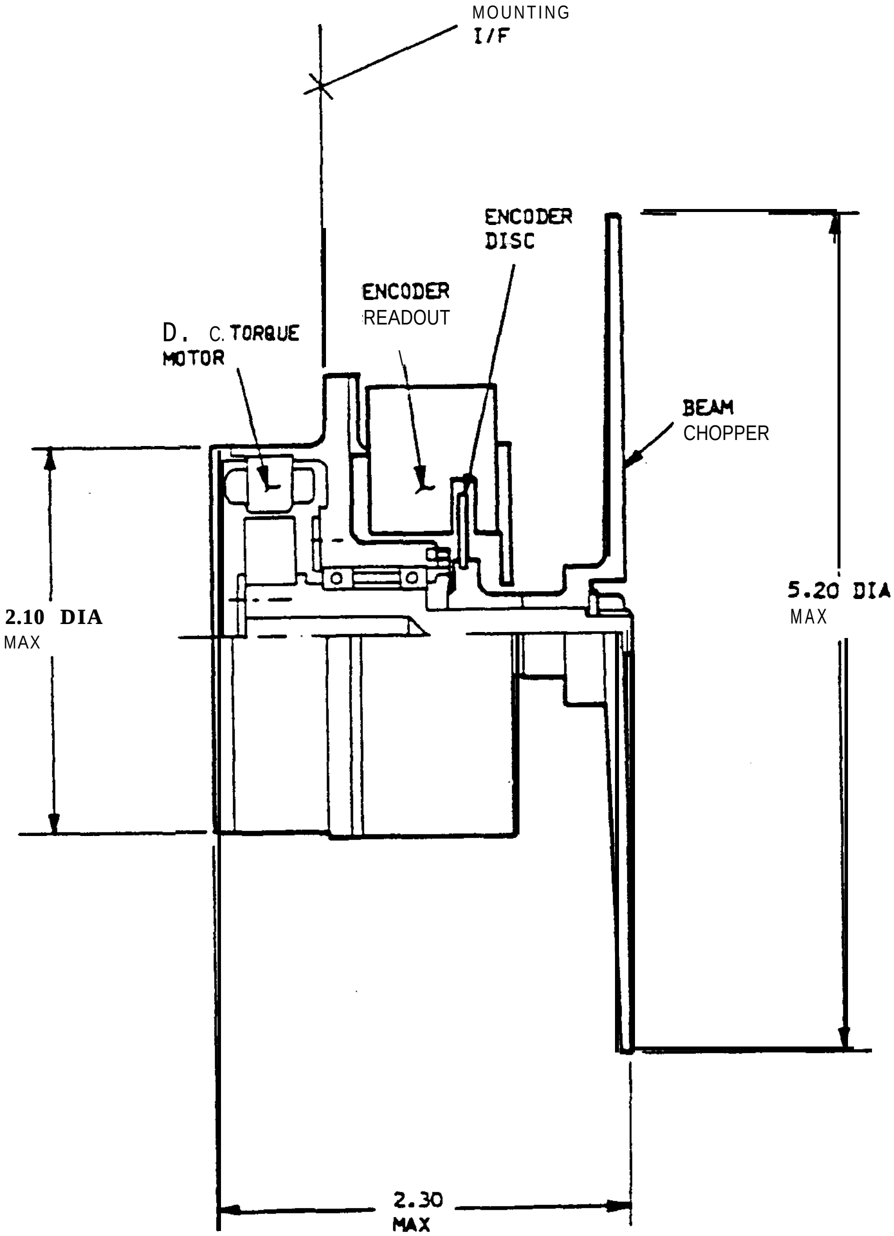

Figure 18.8-21. Cross Section of Chopper Assembly

Table 18.8-7 Chopper Assembly Characteristics

Velocity	240 rpm
Life	2 years continuous operation
Uncompensated Angular Momentum	0.0045 N-M-S
Torque Margin	3X friction
Bearing Quality	ABEC-7
Temperature	
Operating	-10°C to +40°C
Nonoperating	-10°C to +40°C

Table 18.8-8 Chopper Wheel Drive Requirements and Characteristics

Mechanical Characteristics	
Moment of Inertia	2.56 X 10^{-2} oz-in.-sec^2
Starting Friction	0.1 oz-in.
Nominal Running Friction	0.5 oz-in.
Cold Running Friction	1.0 oz-in.
Torque Disturbances	0.75 oz-in. for 0.4 msec
Encoder	
Velocity Track	1000 Cycles per Revolution
Phase Track	5 Cycles per Revolution
Motor Commutation Tracks	3 Tracks, 4 Cycles per Revolution
Motor	
Phases	3
Poles	8
Type	Brushless, dc
Velocity	
Motor Velocity	4 Hz
Velocity Stability	±0.0036 Hz
Phase	
Chopper Phasing	Locked to 20 Hz Demod Signal
Phase Stability	±0.0057 Wheel Radians

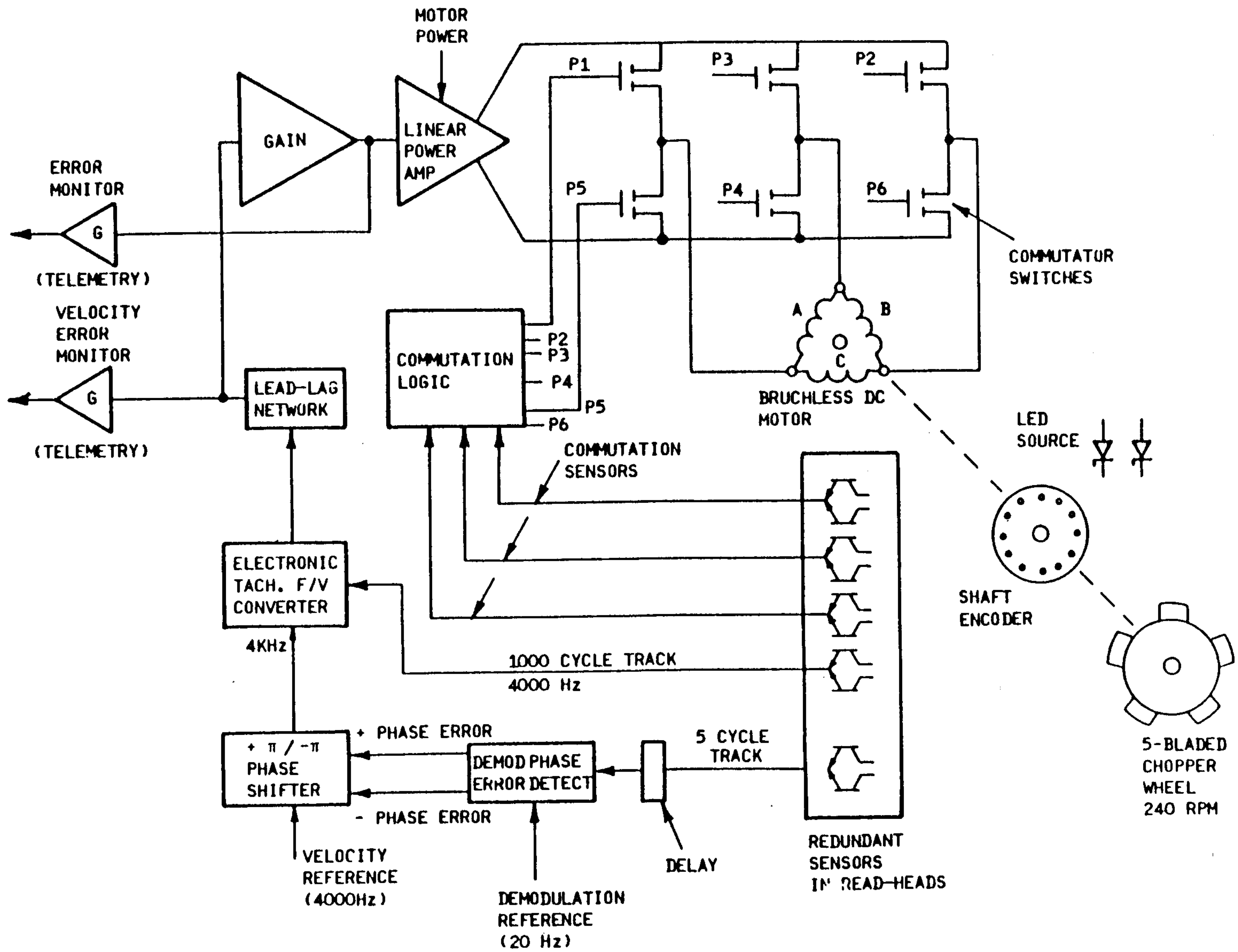

Figure 18.8-22. Block Diagram of Chopper Drive Electronics

Table 18.8-9 Diffuser Positions

Position	Angle-to- Spacecraft X-Axis	Accuracy	Repeatibility
Stow	12”	N/A	N/A
Degradation Check	90”	±1.0°	±0.1°
Solar b-radiance	118°	±0.4°	±0.1°
Decontamination	167.5’	N/A	N/A

The total mechanism is fully operational in any attitude in a 1 g field, positively latched for launch. Performance characteristics are provided in Table 18.8-10, and diffuser drive logic is provided in Figure 18.8-23.

In the Decontamination Mode, the heater power requirement is 5 watts maximum.

18.8.2.7.7 Calibration Lamp Assembly-The calibration lamp assembly is used to provide an in-flight reference source for wavelength calibration of the instrument. It also provides the closure for the instrument aperture during storage and launch. As the reference source, it uses a mercury discharge Pen-Ray lamp in an aluminum housing (Figure 18.8-24). The output face of the housing is a ground fused-silica diffuser.

The lamp puts out several discrete spectral lines (from 184.9 nm to 404.7 nm) within the spectral range of the instrument.

The calibration lamp assembly is used in two positions; in the open position the lamp illuminates the diffuser deployed in its monitor position, and in the closed position the same covers the input apertures and can illuminate them directly. In this position, the lamp diffuser helps to fill the entire field of view of the monochromator.

Comparison of the two sweep mode measurements permits in-flight evaluation [illegible] efficiency so that a correction factor can be applied to the data on the ground if appropriate.

The lamp is operated at a controlled current of 1 .O mA.

Mechanically the assembly is a single-axis rotation, two-position device driven directly by a 90° stepper motor through a reduction gearhead. An optical read-out provides position information. The total mechanism is fully operational in any attitude in a 1 g field but is retained in the closed position for launch. The calibration lamp drive performance characteristics are provided in Table 18.8-11.

Table 18.8-10 Diffuser Drive Performance

Position Accuracy	sun position = 28 + 1°/ − 0	
Position Repeatibility	±0.02°	
Type of *Motor*	45" PM Stepper	
	60Ω per Winding	
	Size 15	
	24 Vdc	
Gear Reduction	180:1	
Step Size	0.25"	
Step Frequency	80 Steps per sec	
Number of Steps	Stow to Mon	378 Steps
	Stow to Sun	490 Steps
	Stow to Decontam	688 Steps
Time Required	Stow to Mon	4.7 sec
	Stow to Sun	6.1 sec
	Stow to Decontam	8.6 sec
Angular Momentum	0.0022 N-M-S Maximum, Instantaneous	
Temperature		
Operating	-10°C to +40°C	
Nonoperating	-20°C to +60°C	

The interlock system between the diffuser and cal lamp drives prevents a mechanical interference problem. The cal lamp must be in the open or closed position before the diffuser can operate, and the diffuser must be stopped before the cal lamp can operate.

The calibration drive logic is provided in Figure 18.8-25.

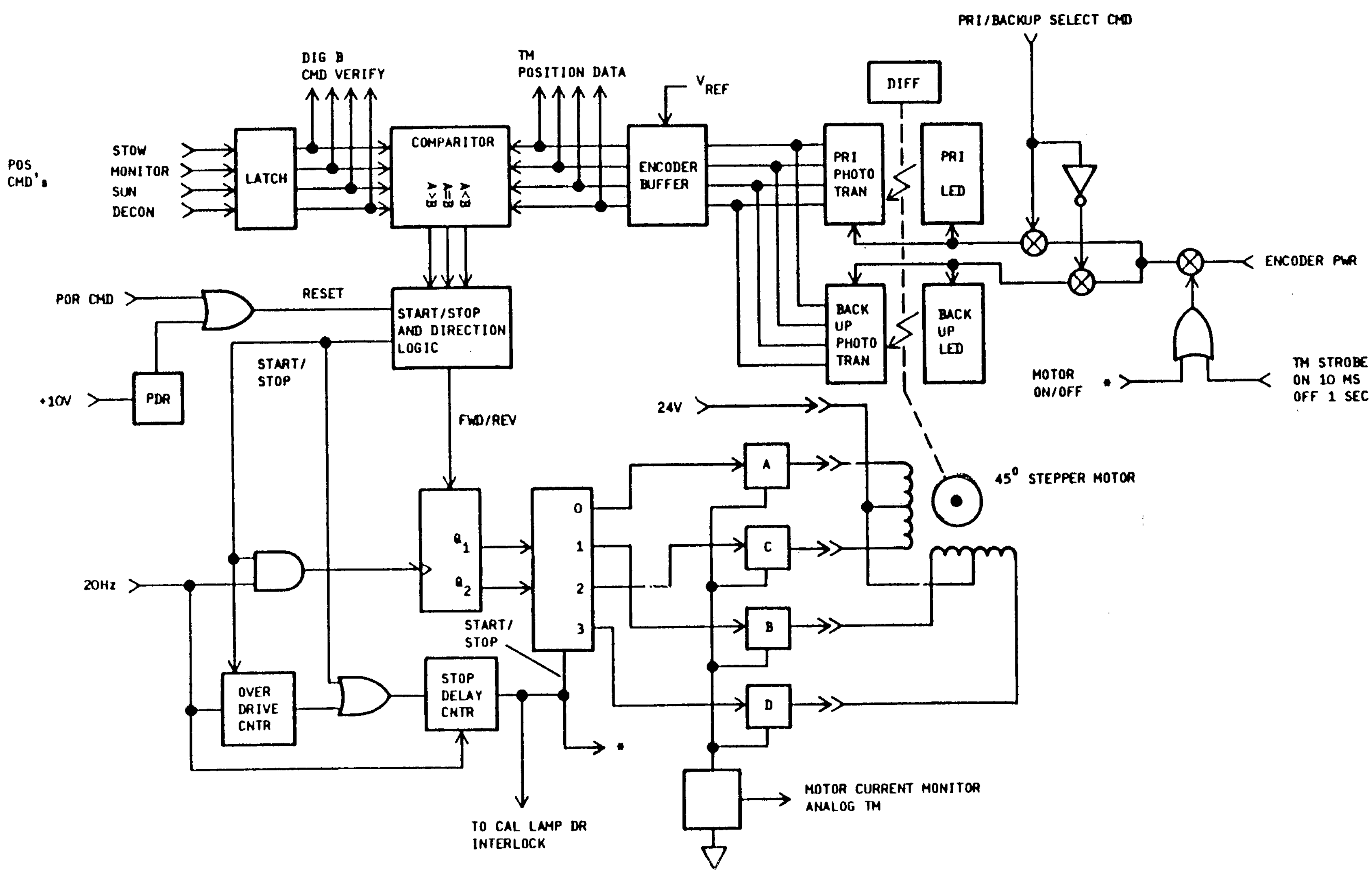

Figure 18.8-23. Diffuser Drive Logic

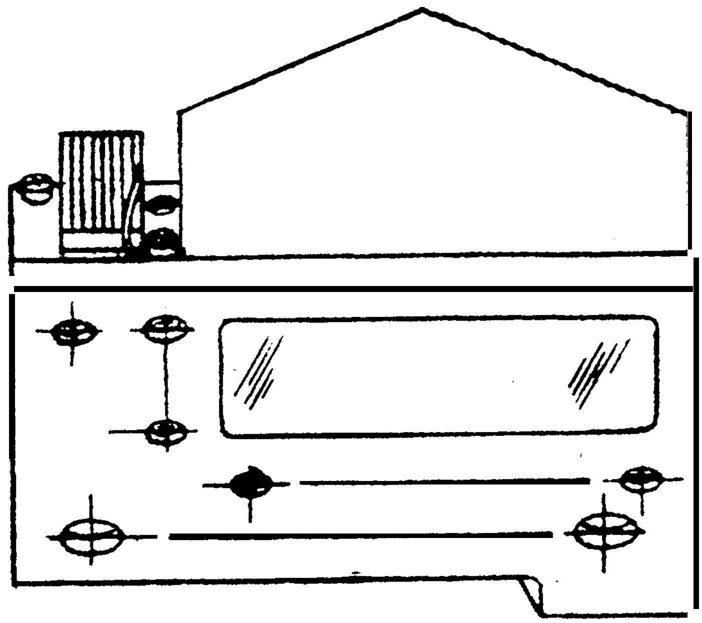

Figure 18.8-24. Calibration Lamp Assembly

Table 18.8-l 1 Calibration Lamp Drive Performance

Type of Motor	90” PM Stepper
	150Ω per Winding
	Size 11
	24 Vdc
Gear Reduction	60: 1
Step Size	1.5”
Step Frequency	20 Steps per sec
Number of Steps	90 Steps
Time Required to Open or Close	4.5 sec
Angular Momentum	0.007 N-M-S Maximum Instantaneous
Stroke	125° Minimum
Positional Accuracy	±1°
Position Repeatability	Spring Loaded Against Both Open and Closed stops
Temperature	
Operating	-10°C to +40°C
Nonoperating	-20°C to +45°C

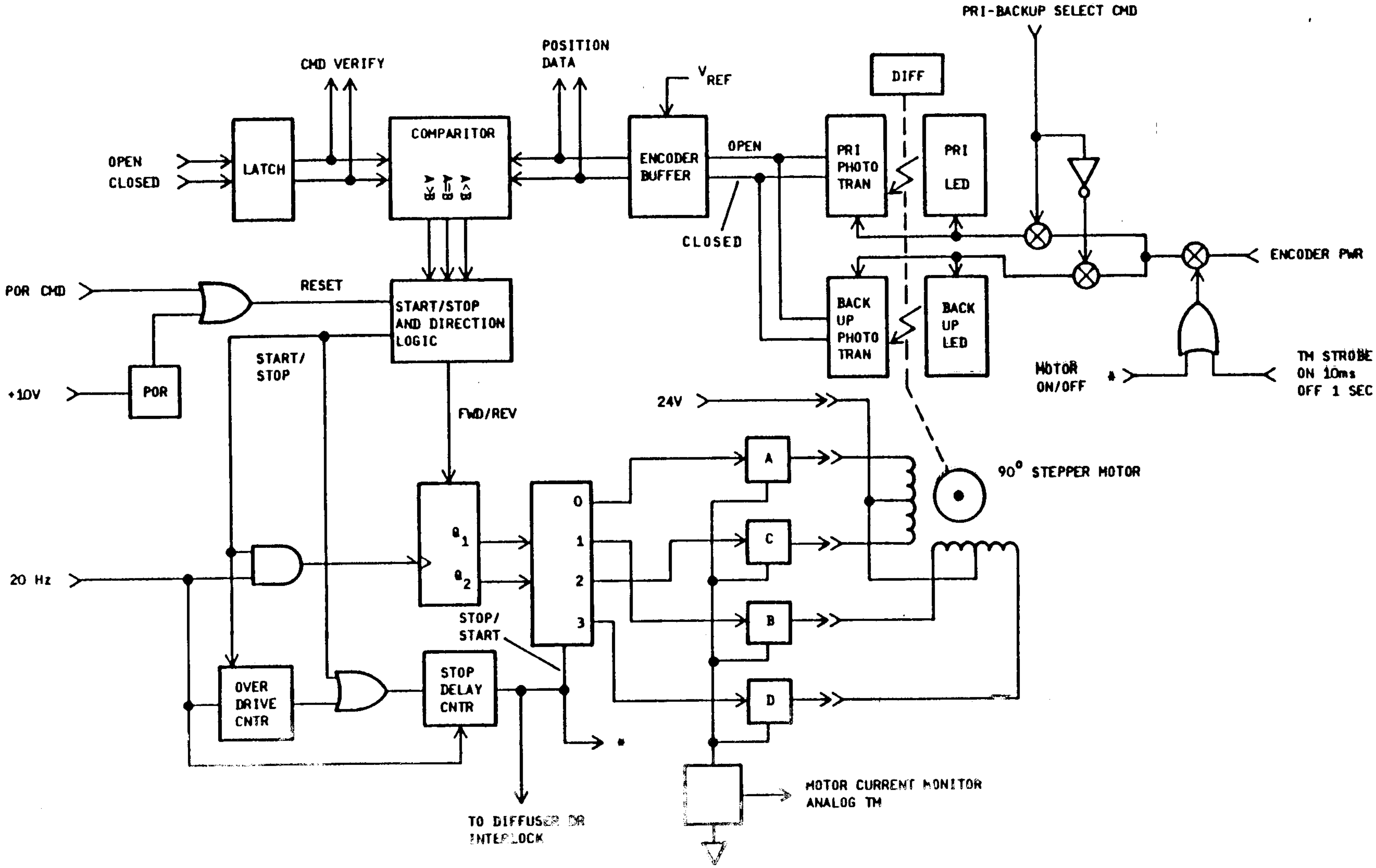

Figure 18.8-25. Calibration Lamp Drive Logic

18.8.2.7.7.1 Calibration Lamp Power Supply-The mercury lamp requires a high starting voltage and a well regulated operating current. A pulse width modulated converter with current feedback is used to meet these requirements. A block diagram of the power supply is shown in Figure 18.8-26. Characteristics of the power supply are listed in Table 18.8-12.

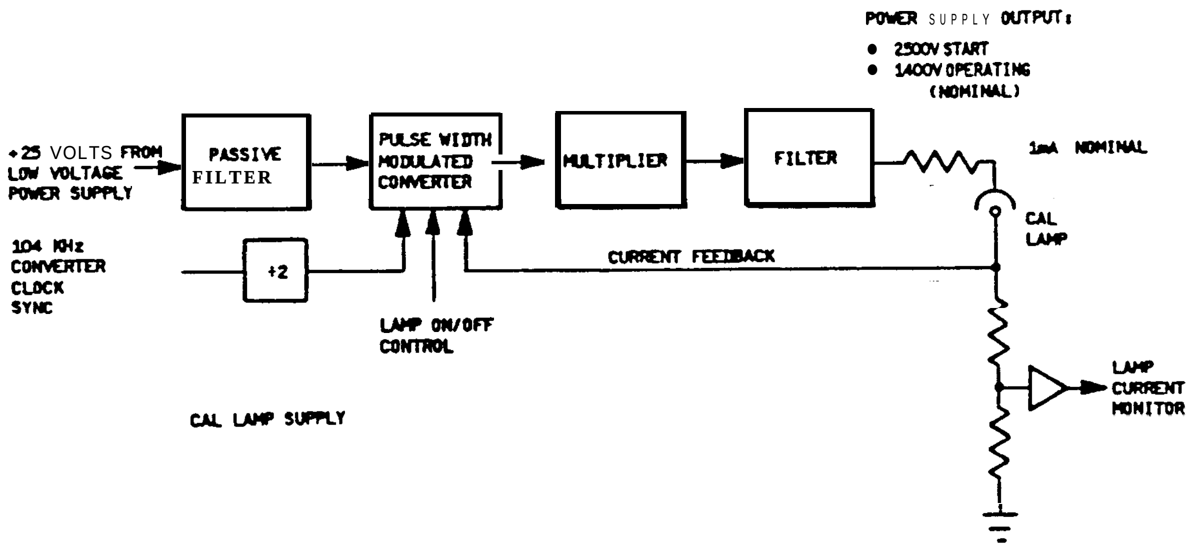

Figure 18.8-26. Block Diagram of the Calibration Lamp Power Supply

18.8.2.7.8 Depolarizer-With its many reflections and two grating diffractions, the monochromator treats input light very nonuniformally, discriminating on the basis of wavelength and polarization state. The depolarizer, which is in the beam immediately before the chopper and entrance slit of the monochromator, scrambles the polarization state of the incoming light so that the monochromator is equally responsive to light of any initial polarization state.

The depolarizer (Figure 18.8-27) uses two Wollaston prisms, each of which includes two quartz wedges with crossed axes. It scrambles by twisting the instantaneous polarization state around the direction in which the ray is going. The twist depends on the location and direction of the ray as it enters the scrambler. The depolarizer is made of optical grade cultured crystalline quartz. This material gives high transmittance and will not degrade measurements by fluorescing. The four optical wedges of the depolarizer are optically contacted to each other (no cement is used, and no internal air or vacuum interfaces exist) for maximum transmission.

18.8.2.7.9 Command System-The SBUV/2 is operated with 39 commands as listed in Table 18.8-13. The status of each command is verified with lines to Digital B telemetry.

Table 18.8-12 Calibration Lamp Power Supply Characteristics

Physical	
Size	2.0 X 3.375 X 5.20 in.
Weight	2.2 lb Measured
Functional	
Input Voltage	+25 Vdc ±2 Vdc
Input Power	≤7 W at 10 mA Load Current
Output Voltage (to start lamp)	2.500 V Minimum
Operating Voltage	12oov to 15oov
Lamp Operating Current	1.0 mA Regulated
Operating Current Regulation	0.1%
Synchronization Frequency	52 kHz; Free Run in Absence of Synchronization
Housekeeping Monitors	Lamp Current, +5 V Full Scale for 3.25 mA

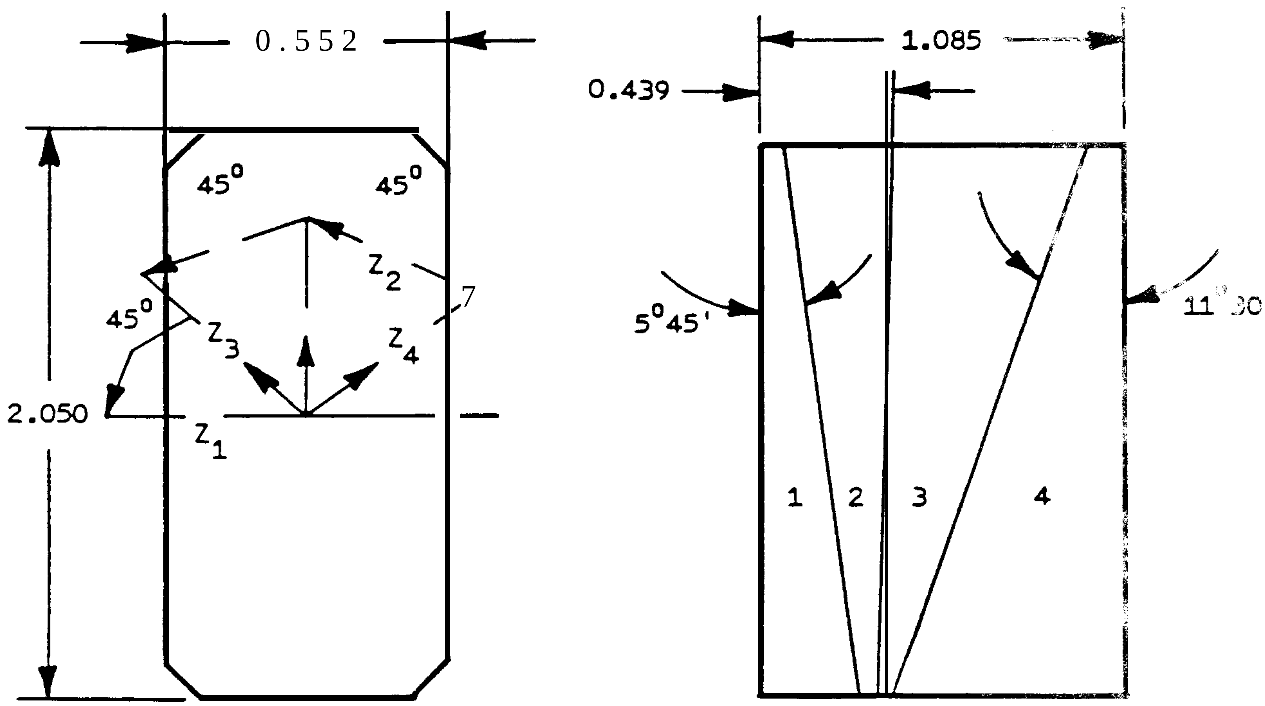

Figure 18.8-27. Depolarizer

Table 18.8-13 List of Commands

Command Designation	Type of Command	Dig. B Reg. No.	Response Mnemonic
1. Master Power On/Lamp Off/H.V. Off	Pulse	1	Master Power On/Off
2. Master Power Off	Pulse		
3. Grating Mode 1 (Discrete)	Pulse	2	Discrete Yes/No
4. Grating Mode 2 (Sweep)	Pulse	3	Sweep Yes/No
5. Grating Mode 3 (λ Cal)	Pulse	4	Cal Yes/No
6. Grating Mode 4 (Position)	Pulse	5	Position Yes/No
7. High Voltage On	Pulse	6	H.V. On/Off
8. Motor Power On	Pulse	7	Motors Power On/Off
9. Motor Power Off	Pulse		
10. Lamp Enable and On	Pulse	8	Lamp On/Off
11. Lamp Disable	Pulse	9	Lamp Disabled/Enabled
12. Lamp Assy Open	Pulse	10	Lamp Assy Open CMD/Close
13. Lamp Assy Close	Pulse		
14. High Voltage Enable	Pulse	11	H.V. Enabled/Disabled
15. Diffuser Position 1 (Stow)	Pulse	12	Diff. Stow CMD, Yes/No
16. Diffuser Position 2 (Monitor)	Pulse	13	Diff. Monitor CMD Yes/No
17. Diffuser Position 3 (Sun)	Pulse	14'	Diff. Sun CMD, Yes/No
18. Diffuser Position 4 (Decontaminate)	Pulse	15	Diff. Position CMD, Yes/No
19. Chop Encoder Sensor, PRI/Bkup	Level	16	Ch Enc Sens PRI/Bkup
20. Grating Encoder Sensor, PRI/Bkup	Level	17	Grat Enc Sens PRI/Bkup
21. Diffuser Position Sensor, PRI/Bkup	Level	18	Diff. Pos'n Sens PRI/Bkup
22. Lamp Position Sensor, PRI/Bkup	Level	19	Lamp Position Sens PRI/Bkup
23. Grating Drive MEM, FIX/FLEX	Level	20	Grating Drive FIX/FLEX
24. Code Strobe*	Pulse	Dig A	
25. Code Address A	Level	Dig A	
26. Code Address B	Level	Dig A	
27. Code Data Bit 1	Level	Dig A	
28. Code Data Bit 2	Level	Dig A	
29. Code Data Bit 3	Level	Dig A	
30. Code Data Bit 4	Level	Dig A	
31. Code Data Bit 5	Level	Dig A	
32. Code Data Bit 6	Level	Dig A	
33. Cal Lamp Heater On	Pulse	21	Cal Lamp Heater On/Off
34. Decontam Heater On	Pulse	22	Decontam Htr On/Off
35. Heaters Off	Pulse		
36. Spare	Pulse		
37. Discrete Sun Enable	Pulse	Dig A	
38. Sweep Sun Enable	Pulse	Dig A	
39. λ Cal Enable	Pulse	Dig A	

*Commands 25-33 used to load grating drive flex memory.

The Master Power On command applies power to the instrument, initializes all control logic, resets the high voltage and lamp power relay to OFF, and returns the grating drive to its home position. The grating mode commands are designed not to depend on any previous mode command (there are no toggling sequences). The last mode command sent takes effect after completion of the current sequence.

The 39 available commands consist of 26 pulse and 13 level commands. The pulse commands are used for power control and quick reaction mode changes. The command system block diagram is shown in Figure 18.8-28. Three pulse commands (nos. 37, 38, and 39) are used to initiate automatic command sequences.

18.8.2.7.10 Data Handling System-The data handling block diagram is shown in Figure 18.8-29. Frequency counters are provided for the electrometer and the housekeeping voltage-to-frequency converters. The counters synchronously demodulate and integrate the modulated frequencies by counting up while the chopper aperture is open and counting down while the aperture is closed. In this manner the background signal is subtracted from the desired signal. The integration time is 1.25 seconds in the discrete, wavelength calibrating and position modes and 0.1 second in the sweep mode.

The contents of each counter are buffered after each integration period and reset for a new integration. The buffered data, as well as submultiplexed digital housekeeping data, are multiplexed out to the 320-bit output data register where it is read out by the TIP. Logic is provided [illegible] PMT range selection when in the sweep mode. Analog housekeeping and digital housekeeping are multiplexed into a serial data stream and loaded into the 320-bit register.

Multiplexing is controlled by fixed format logic which utilizes timing and synchronization signals derived from the TIP interface. The output data register is completely loaded once per second at a high clock rate, in between read-out periods. Data are read out by the TIP every 1/20 second in 16-bit groups.

18.8.2.7.10.1 Digital A Telemetry Lists and Formats-The SBUV/2 format consists of 20 16-bit words telemetered every second for a total data rate of 320 bps. This format is changed only in the sweep mode to accommodate higher monochromater data rates. Only two formats are [illegible] shown in Table 18.8-14: a discrete mode format and a sweep mode format. Word 1 column. contains the CCR data and all housekeeping data, and remains fixed in both discrete and [illegible] Word 2 is devoted to PMT data, containing the data from all three in the discrete mode format This word is switched in the sweep mode to read only the selected PMT Range Data.

The 16-channel analog submultiplexer and the digital status register, both located in the ELU, provide ample capacity for housekeeping and status. Data assignments for the analog submultiplexer are listed in Table 18.8-15. The analog submux data consist of 8-bit samples which are packed two per 16-bit word. Data assignments for digital status words are listed in Table 18.8-16. There are spare channels of both analog and digital data for possible future expansion.

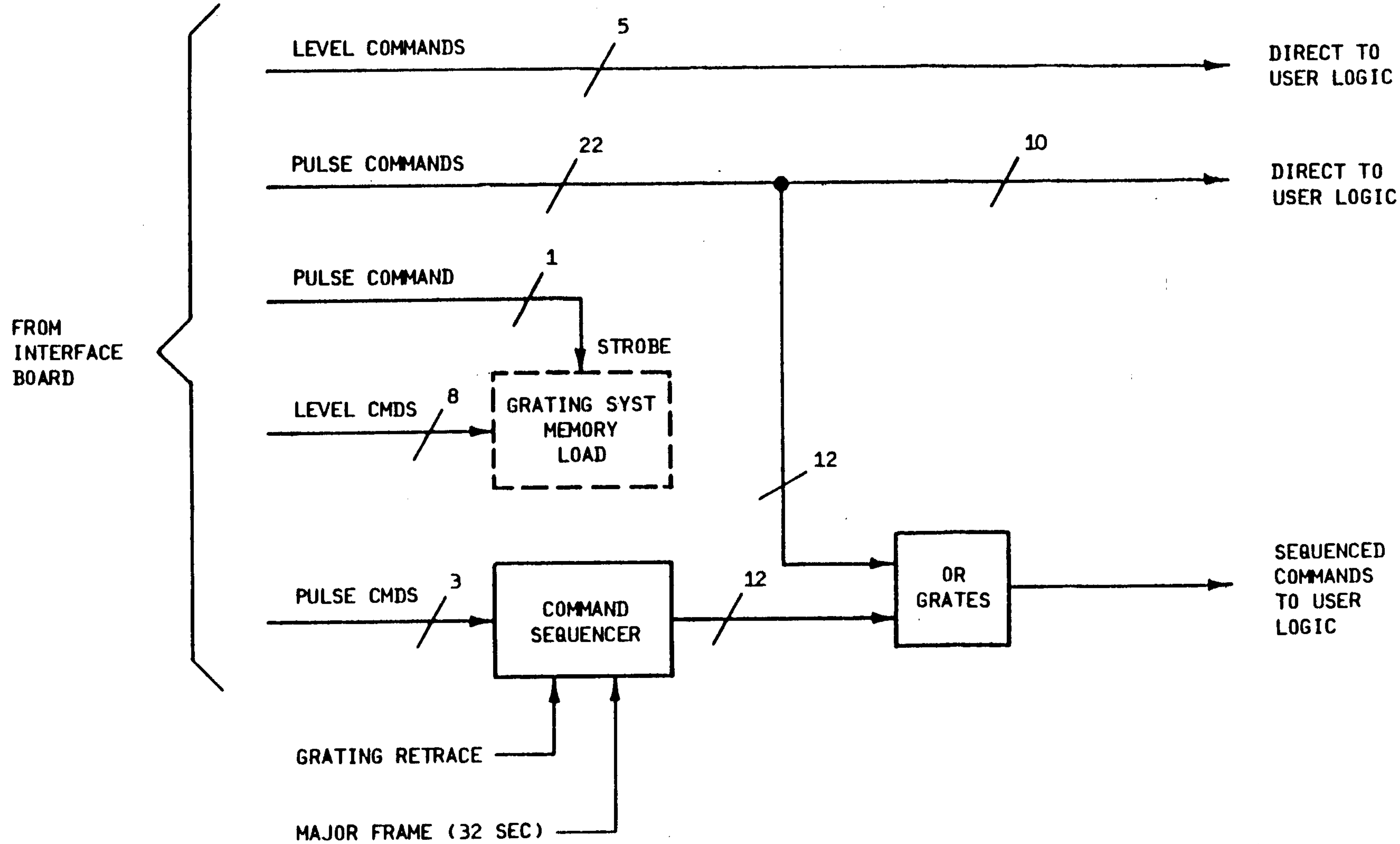

Figure 18.8-28. Block Diagram of Command System

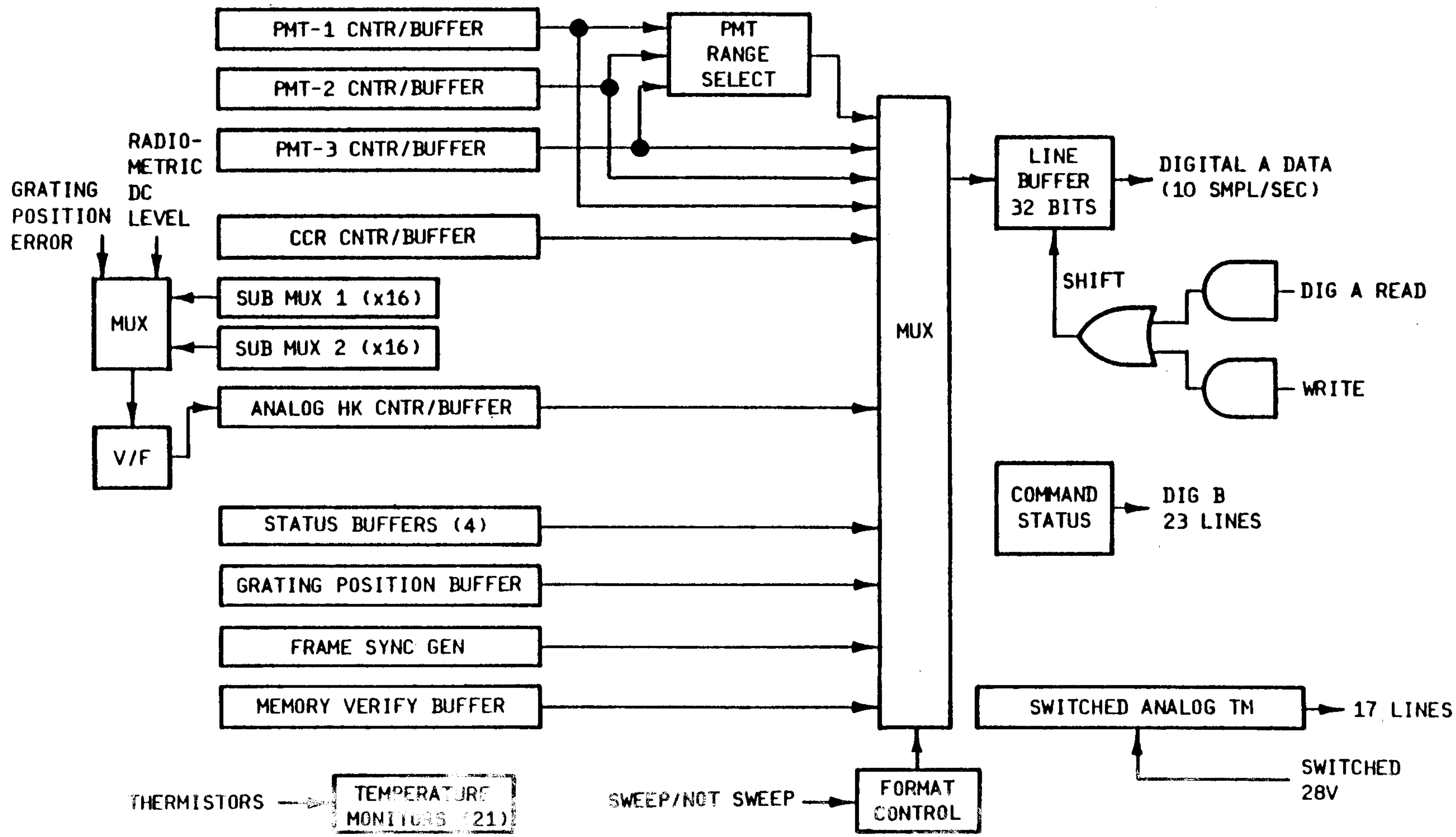

Figure 18.8-29 Block Diagram of Data Handling System

Table 18.8-14 Digital A Data Formats (1) (2)

Discrete Modes	Word 1	Word 2
Line 0	Status 1	PMT Range 1 Data
Line 1	Status 2	PMT Range 2 Data
Line 2	Analog Sub Mux	PMT Range 3 Data
Line 3	Memory Verify	*Spare*
Line 4	Status 3	Spare
Line 5	Status 4	Spare
Line 6	Grating Position	Spare
Line 7	CCR Data	Spare
Line 8	Radiometric dc Level and Grating Pos Error	Spare
Line 9	Frame Sync Code	Spare
Sweep Modes	**Word 1**	**Word 2**
Line 1	Status 1	PMT Selected Range Data
Line 2	Status 2	PMT Selected Range Data
Line 3	Analog Sub Mux	PMT Selected Range Data
Line 4	Memory Verify	PMT Selected Range Data
Line 5	Status 3	PMT Selected Range Data
Line 6	Status 4	PMT Selected Range Data
Line 7	Grating Position	PMT Selected Range Data
Line 8	CCR Data	PMT Selected Range Data
Line 9	Radiometric dc Level (3)	PMT Selected Range Data
Line 10	Frame Sync Code	PMT Selected Range Data

Notes: 1. **All** words are 16 bits; analog channels are encoded with two 8-bit samples per 16-bit word.

2. Rate is ten lines per second.

Table 18.8-15 Digital A Analog Submultiplexer Data Assignments

Channel No.	Function Name	Channel No.	Function Name
1A	Chopper Motor Current	1B	Spare
2A	Diffuser Motor Current	2B	Diffuser Plate Temp (0 80)
3A	HVPS Volts	3B	SM Baseplate Temp (-15 45)
4A	Thermistor Bias (10 V Ref)	4B	25 V Power (Volts!
5A	Cal Lamp Temp (0 80)	5B	15 V Servo (Volts)
6A	ECAL Ref	6B	-15 V Servo (Volts)
7A	15 V Sensors (Volts)	7B	CCR Diode Temp (-5 35)
8A	-15 V Sensors (Volts)	8B	SM Diff Temp Y-axis (±5°C)
9A	24 V Motor (Volts)	9B	SM Diff Temp Z-awis (±5°C)
10A	5 V LED (Volts)	10B	Diff Ref Temp Z-axis
11A	10 v Logic (Volts)	11B	Diff Ref Temp Y-axis
12A	Calibration Lamp Current	12B	PMT Cathode Temp (-[illegible])
13A	Spare	13B	Spare
14A	Spare	14B	Chopper Phase Err.
15A	Spare	15B	Spare
16A	Lamp Motor Current	16B	Spare

18.8.2.7.10.2 Analog Telemetry-The analog telemetry consists of 17 conditioned analog house keeping monitors wired directly to the TIP; these channels are listed in Table 18.8-1[illegible]

18.8.2.7.10.3 Digital B Telemetry-The status of each command is verified with 22 [illegible] Digital B telemetry as listed in Table 18.8-18.

18.8.2.8 Constraints

18.8.2.8-l General-The following are general constraints:

- The depolarizer temperature must be maintained greater than -10°C and less than 40°C

Table 18.8-16 Digital A Status Words

Status Word 1

BIT	USE	LOGIC 1 (GND)	STATE 0 (+)
1	Master Power ON/OFF	OFF	ON
2	Discrete Mode/Sweep Mode Format	DISCRETE	SWEEP
3	Sweep Mode Major Frame Word 2^2	True	False
4	Sweep Mode Major Frame Word 2^1	True	False
5	Sweep Mode Major Frame Word 2^0	True	False
6	Retrace	ON	OFF
7	16 sec (2^2)	True	False
8	8 sec (2^1)	True	False
9	4 sec (2^0)	True	False
10	Command Sequence (2^2)	True	False
11	Command Sequence (2^1)	True	False
12	Command Sequence (2^0)	True	False
13	Range ID B-L0	ON	OFF
14	Range ID A-L0	ON	OFF
15	Range ID B-L1	ON	OFF
16	Range ID A-L1	ON	OFF

Status Word 2

BIT	USE	LOGIC 1	STATE 0
1	Range ID B-L2	ON	OFF
2	Range ID A-L2	ON*	OFF
3	Range ID B-L3	ON	OFF
4	Range ID A-L3	ON	OFF
5	Range ID B-L4	ON	OFF
6	Range ID A-L4	ON	OFF
7	Range ID B-L5	ON	OFF
8	Range ID A-L5	ON	OFF
9	Range ID B-L6	ON	OFF
10	Range ID A-L6	ON	OFF
11	Range ID B-L7	ON	OFF
12	Range ID A-L7	ON	OFF
13	Range ID B-L8	ON	OFF
14	Range ID A-L8	ON	OFF
15	Range ID B-L9	ON	OFF
16	Range ID A-L9	ON	OFF

Status Word 3

BIT		LOGIC 1	STATE 0
1	R1 Over/Range	O/R	On Scale
2	R2 Over/Range	O/R	On Scale
3	R3 Over/Range	O/R	On Scale
4	CCR Over/Range	O/R	On Scale
5	Code Address A	1	0
6	Code Address B	1	0
7	Code Data 1	1	0
8	Code Data 2	1	0
9	Code Data 3	1	0
10	Code Data 4	1	0
11	Code Data 5	1	0
12	Code Data 6	1	0
13	Discrete Sun Enable	ON	OFF
14	Sweep Sun Enable	ON	OFF
15	λ Cal Enable	ON	OFF
16	Spare	Always Off	

Status Word 4

BIT	USE	LOGIC 1	STATE 0
1	Diffuser Stow Pos	Stow	Not Stowed
2	Diffuser Monitor Pos	Monitor	Not Monitor
3	Diffuser Sun Pos	Sun	Not Sun
4	Diffuser Decontam Pos	Decontam	Not Decontam
5	Discrete Mode	ON	OFF
6	Sweep Mode	ON	OFF
7	Diffuser Pos Valid	Valid	Not Valid
8	Diffuser Timer	Time Out	Not Time Out
9	Calib Lamp Open	OPEN	NOT OPEN
10	Calib Lamp Closed	CLOSED	NOT CLOSED
11	Calib Lamp Pos Valid	Valid	Not Valid
12	Calib Lamp Timer	Time Out	Not Time Out
13	Cal Mode	ON	OFF
14	Position Mode	ON	OFF
15	Grating Fix/Flex	FIX	FLEX
16	Grating Index Found	Found	Not Found

*Diffuser count bits and Cal Lamp count bits indicate which stepper motor winding is being activated.

Table 18.8-17 Analog Telemetry List

1.	SM Baseplate Temp. #2 (-15 to +45)*
2.	SM Structure Temp. (-15 to +45)
3.	Depolarizer Housing Temp. (-15 to +45)
4.	HVPS Temp. (-15 to +45)
5.	Diffuser Plate Temp. #2 (0 to +80)*
6.	Chopper Motor Temp. (-15 to +45)
7.	Grating Motor Temp. (-15 to +45)
8.	Diffuser Motor Temp. (-15 to +45)
9.	Cal Lamp Motor Temp. (-15 to +45)
10.	Electrometer Temp. (-15 to +45)
11.	Cal Lamp Power Supply Temp. (-15 to +45)
12.	Diffuser Radiator Temp. (-15 to +45)
13.	ELM Temp. (-15 to +45)
14.	LVPS Temp. (-15 to +45)
15.	Diffuser Heater Current
16.	Baseplate Heater Current
17.	28 V Main Power Voltage

*Powered from the 28 V switched telemetry bus.

- The instrument temperature as measured at the spacecraft interface must be maintained:
  - Greater than or equal to 0°C and less than or equal to +30°C for in-spec. operation
  - Greater than -10°C and less than +40°C for survival.
- When the instrument is off:
  - The diffuser must be stowed.
  - The calibration lamp housing must be closed.
  - High voltage must be inhibited.
- The high voltage must not be turned on when the pressure is greater than 5 X 10^{-5} torr except at room ambient.
- The purge line cap must be installed on purge system intake whenever the purge line is removed.

Table 18.8-18 Digital B Telemetry Data Assignments

No.	Function	Logic State 1(GND)	0 (+5 V)
1	Master Power On/Off	OFF	ON
2	Discrete Yes/No*	Yes	No
3	Sweep Yes/No*	Yes	No
4	Cal Yes/No*	Yes	No
5	Position Yes/No*	Yes	No
6	HVPS On/Off	Off	On
7	Motor Power On/Off	Off	On
8	Lamp On/Off	Off	On
9	Lamp Disabled/Enabled	Disable	Enable
10	Lamp Assy Open Cmd/Close Cmd*	Open Cmd	Close Cmd
11	HVPS Enabled/Disabled	Disabled	Enabled
12	Diffuser Stow Cmd Yes/No*	Yes	No
13	Diffuser Mon. Cmd Yes/No*	Yes	No
14	Diffuser Sun Cmd Yes/No*	Yes	No
15	Diffuser Decontam Cmd Yes/No*	Yes	No
16	Chopper Encoder Sensor Pri/Bkup	Pri	Bkup
17	Grating Encoder Sensor Pri/Bkup	Pri	Bkup
18	Diffuser Position Sensor Pri/Bkup	Pri	Bkup
19	Lamp Position Sensor Pri/Bkup	Pri	Bkup
20	Grating Drive Fix/Flex*	Fix	Flex
21	SM Baseplate Heater ON/OFF	Off	On
22	Diffuser Decontamination Heater ON/OFF	Off	On

*Bit set indicates last command received. Command action may or may not have been completed.

18.8.2.8.2 Prelaunch Phase

a. Contamination covers must remain in place on the Sensor Module for testing.

b. The Sensor Module must be continually purged with dry N_2 whose cleanliness has been previously verified.

c. Personnel working around the Sensor Module, particularly when the contamination covers are removed, must wear clean gloves, hoods, and facemasks. During the brief periods when the covers are removed while the instrument is mounted on the spacecraft, no work shall be done above the SBUV/2.

d. The carbon filter must be installed on the purge line intake during spacecraft T/V testing and when the spacecraft is in its shipping container.

18.8.2.8.3 Launch Phase

a. Verify that dust covers are removed prior to launch.

b. Verify that the diffuser is stowed and the calibration lamp housing closed over the entrance aperture. The SBUV/2 must be off for launch.

c. Verify that the carbon filter has-been removed.

d. Verify that the purge line cap is installed on the purging system intake.

18.8.2.8.4 Activation Phase

a. Initial tumon sequence

1. Instrument Power - ON
2. Grating Memory - FIXED
3. Chopper Encoder Sensor - PRIMARY
4. Grating Encoder Sensor - PRIMARY
5. Lamp Position Sensor - PRIMARY
6. Diffuser Position Sensor - PRIMARY
7. Diffuser Position (1) - STOW
8. Lamp Assembly - CLOSED
9. Motor Power - ON
10. Instrument Power - ON

NOTE: The following two commands are not to be sent initially without [illegible] from NASA and not before postlaunch day 15. In this interval during, inst[illegible] A&E, the grating drive system will be exercised.

11. High Voltage - ENABLE
12. High Voltage - ON

NOTE: The following command is not to be sent initially without go-ahead from NASA and not before postlaunch day 30. In this interval during A&E, the grating drive and fix/flex memory systems will be exercised and wavelength calibration data will be collected.

13. Lamp Assembly – OPEN

NOTE: Initial deployment of the diffuser will not occur without go-ahead from NASA and not before postlaunch day 37.

18.8.2.8.5 Operational Phase-Activation of the Discrete Sun Enable and Sweep Sun Enable command sequences must be time-correlated with that portion of each orbit during which the Sun is available for observation.